AGRICULTURAL ENGINEERING

SEPTEMBER • 1954

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Use of Sol-Air Temperature Measurements in Animal-Shelter Studies

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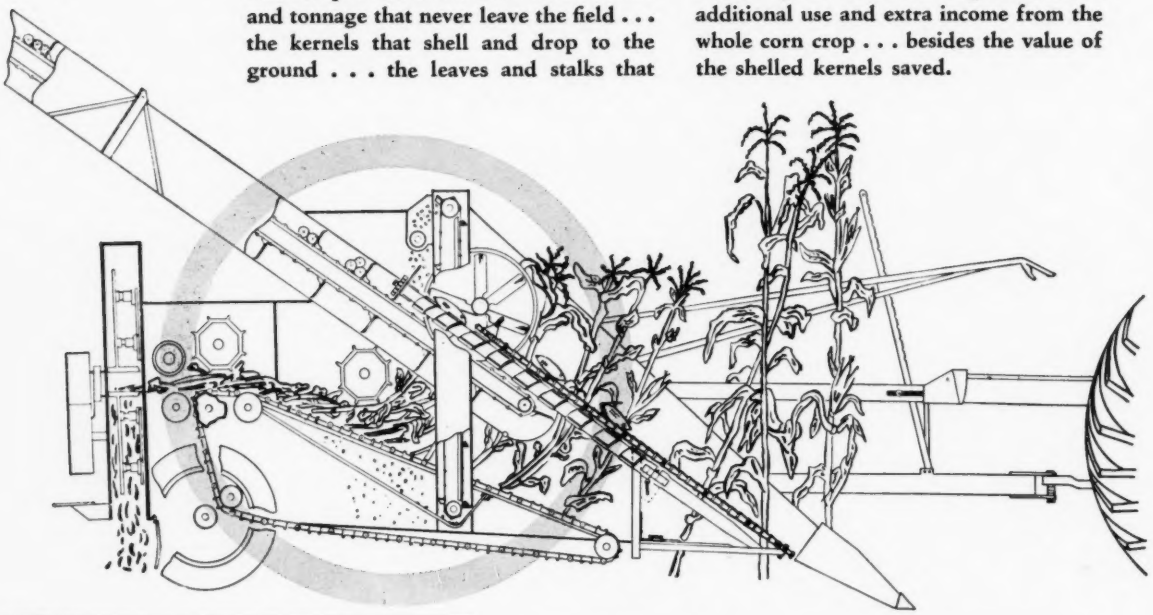
Design Requirements of Pneumatic Systems for Conveying Feeds from Storage

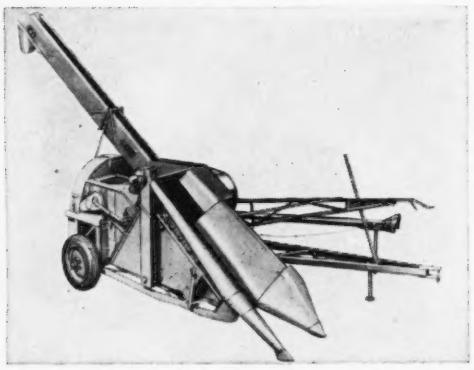
ASAE Winter Meeting • Chicago, Ill., December 6 to 8

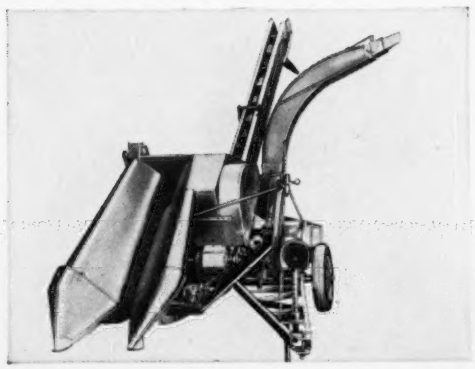
THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Saves THE LOST BUSHELS

Only that part of the corn crop that's either sold or fed puts money in the farmer's pockets. But what of those bushels and tonnage that never leave the field . . . the kernels that shell and drop to the ground . . . the leaves and stalks that could make dry roughage, low-cost silage . . . excellent bedding? Salvage of this part ordinarily lost would be a big windfall . . . additional use and extra income from the whole corn crop . . . besides the value of the shelled kernels saved.







That's why Case dug deep to serve, to give farmers a way of full use of their corn crop. Via the routes of research and design, Case engineers have developed a machine that saves bushels per acre, the loss usually incurred by mechanical picking. Kernels ordinarily lost going through picking rolls drop to a floor underneath the stalkway. A chain rake, in turn, delivers them to the elevator where they join the ears on the way to the wagon. The drawing above and the photo to the left show this new, shielded feature.

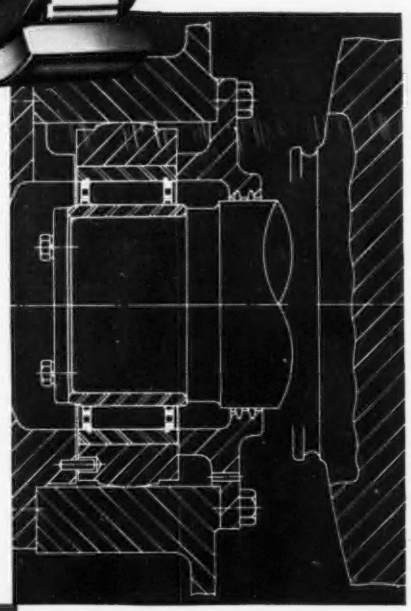
There's an equally great crop-salvage feature, one that provides a new kind of bonus to cost-conscious farmers. In the same operation of picking, the Case Corn Harvester chops or shreds stalks and leaves. In terms of crop savings, it takes tough vegetation . . . cuts it into desired lengths and blows it into a forage wagon for low-cost, filling feed or absorbent bedding. For those who prefer, it chops or shreds stalks into fine material . . . returns it direct to the ground for rapid decay, also making plowing and disking much easier and faster. At left is the Corn Harvester equipped to deliver chopped stover into trucks or wagons. J. I. Case Co., Racine, Wis.

CASE

Is shaft expansion a problem?

HERE'S HOW HYATTS HELP...

Hyatt Hy-Loads are available in separable outer race, separable inner race or non-separable construction.



Check the drawing at the left. The bearing is a Hyatt Hy-Load, and because the inner race is cylindrical, the shaft it supports is free to move axially—thus allowing for shaft expansion without cramping the bearing or distorting the shaft. Obviously, this is only one of many ways in which Hyatt bearings can be used to reduce costs as they reduce friction, but it's a good example of why so many designers throughout industry keep their Hyatt catalogs within easy reach.

For further details write for Catalog 150 or call your nearest Hyatt representative.

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

AGRICULTURAL ENGINEERING

Established 1920

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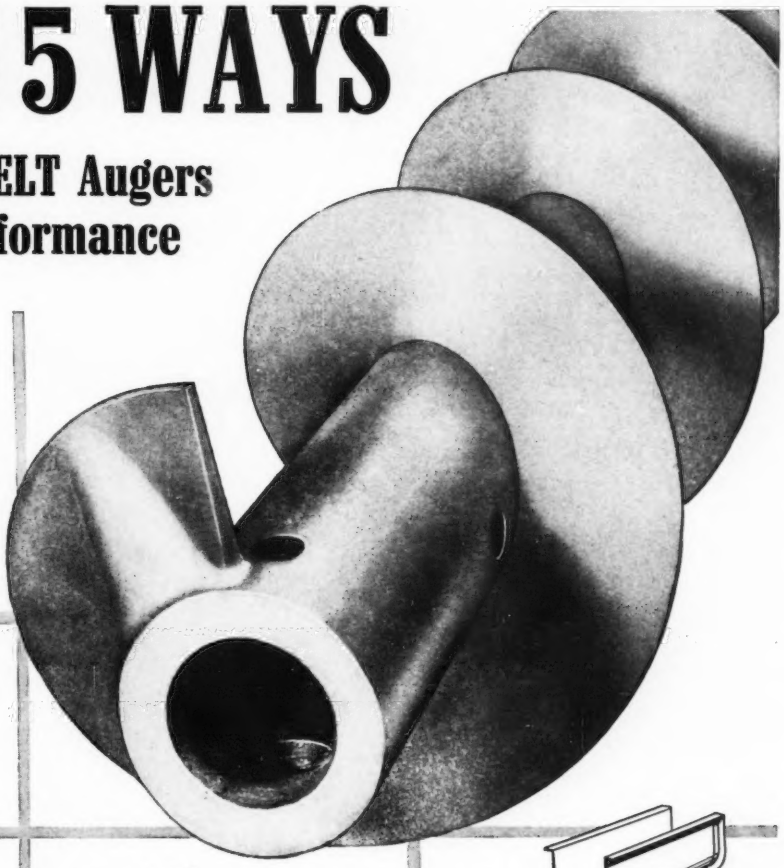
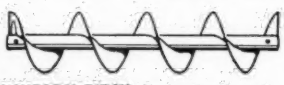
SCORES 5 WAYS

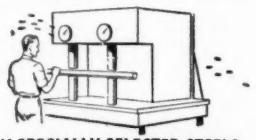
See why LINK-BELT Augers assure top performance



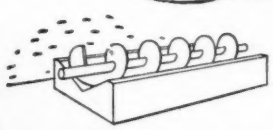
1 ONE-PIECE HELICOID FLIGHTING has greater smoothness and strength. Link-Belt also builds many different shapes in various metals to meet your special needs—cut flight, short pitch, ribbon flight, tapering, double flight to name a few.



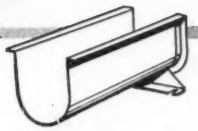
2 UNIFORM PITCH. Specialized modern machinery assures accurate forming, producing uniform flighting curvature.



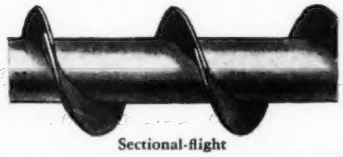
3 ONLY SPECIALLY SELECTED STEELS are used to meet Link-Belt's rigid inspections—assuring smooth flight surfaces.



4 STRAIGHTNESS is checked before shipping assemblies. Extra care is taken in handling and loading.



5 ALL COMPONENTS needed can be supplied by Link-Belt, specially engineered for your requirements. This includes troughs, spouts, hangers, drives.



Sectional-flight

Helicoid flight with end, plain beater

Helicoid flight

Unmounted Helicoid flighting

TYPICAL EXAMPLES OF LINK-BELT AUGERS

Opposed flights with center saw-tooth beater

These are only a few of the many important differences in farm machine augers. Ask your Link-Belt sales representative for 92-page Data Book 2289

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13,385

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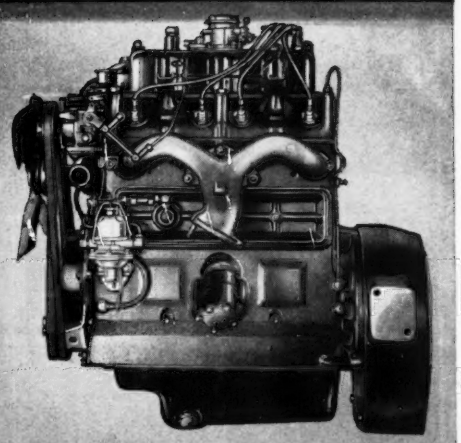
4 MODELS
4 and 6 CYLINDERS
.403 TO .559 Hp / CU. IN. DISPL.

"JOHN" WILLYS *

Engine Chalk Talk

I wanted to be one of the first to let you know that we at Willys have designed four POWER GIANT Engines just for industrial uses. They're based on proven designs . . . with "proven-in-action" features known for ruggedness from the Arctic to the Tropics. And, they incorporate the same low maintenance, high efficiency characteristics of all Willys designs. As for torque and power, the POWER GIANTS are right up top in their weight and displacement class. For rugged power needs, investigate these POWER GIANTS.

* Design Department, Willys Motors, Inc.



Willys **POWER GIANT** Industrial Engines and Power Units

INDUSTRIAL ENGINES and POWER UNITS

Model	Cyl. and Head	Displ. Cu. in.	Range Max. bhp	Range of speed
Jeep	4 L	134.2	22 - 60	1200 - 4000
Hurricane	4 F	134.2	22 - 70	1200 - 4000
Lightning	6 L	161.0	28 - 75	1200 - 4000
Giant Hurricane	6 F	161.0	28 - 90	1200 - 4200

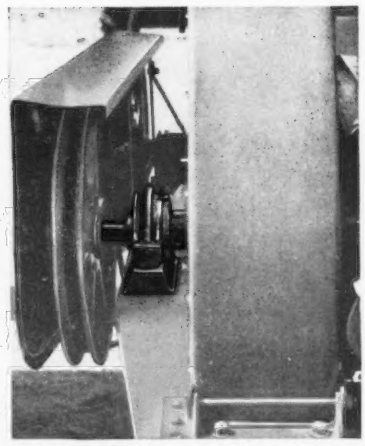
SEND FOR POWER GIANT BULLETINS
4 Cylinder Engines
6 Cylinder Engines
Power Units

PROVEN IN ACTION

WILLYS MOTORS, INC. *Industrial Engine Department*
1465 NORTH COVE BLVD. TOLEDO, OHIO

The Gehl Forage Harvester with hay pick-up attachment.

. . . for a cost-reducing "hired hand"



Flywheel on the main unit of the Gehl Forage Harvester illustrating the use of a pillow block with Fafnir Wide Inner Ring Ball Bearing.

Labor-saving convenience and job-handling versatility are but two of many dependable qualities that make the Gehl Forage Harvester a star performer on today's modern farms. Of equal importance to busy owners are its smooth, friction-free performance and low cost maintenance record — added advantages resulting from the use of ball bearings at major turning points.

Take, for example, the six-knife unbreakable flywheel on the main unit. Here, to conserve power and accommodate heavy radial and thrust loads on the shaft, Gehl engineers have installed heavy duty Fafnir Wide Inner Ring Ball Bearings with Self-Locking Collars. Equipped with efficient seals to protect against contaminants and loss of lubricants, these Fafnir ball bearings assure long, trouble-free operation with minimum servicing . . . help uphold the famed Gehl reputation for quality equipment that "gets the big jobs done quickly, easily and on time."

Like other leading farm equipment manufacturers, Gehl has turned to Fafnir for the precise answers to bearing problems on many occasions. Each time they have found valuable help in the Fafnir "attitude and aptitude"— a way of looking at bearing problems from a designer's point of view plus the ability to provide the right bearing to fit the need. Perhaps this combination can help you, too. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

New Holland equips New Super "77" Baler with Dayton V-Belts

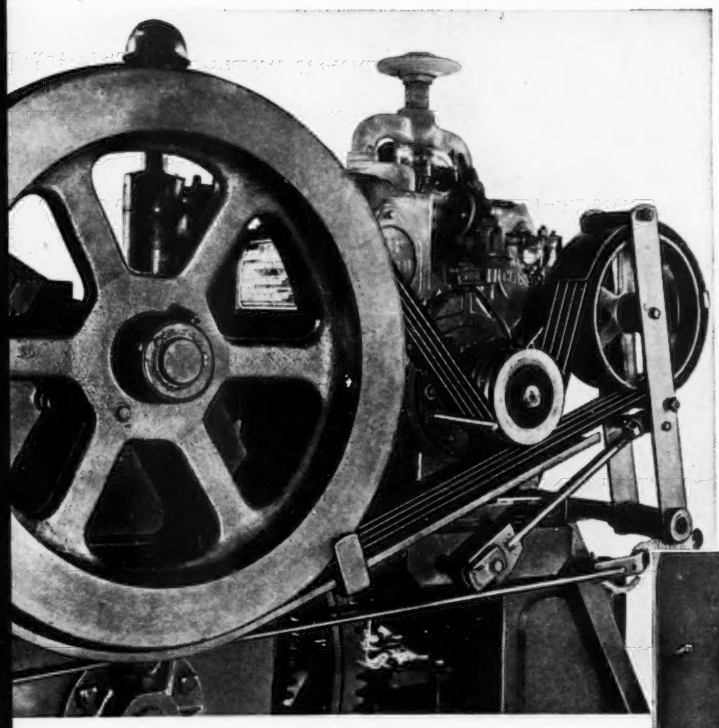
New Super "77" baler, developed by New Holland Machine Co., New Holland, Pa., employs 5 Dayton V-Belts to set 12-ton-an-hour record

Here's a baler designed for the farmer or custom operator who needs or wants increased capacity. Fully equipped with Dayton V-Belts, the Super "77" averaged an unprecedented *12 tons an hour* in carefully timed runs on private farms. Under good to ideal conditions even higher tonnage has been recorded.

Powered by a new VF-4, 24 HP, four-cylinder, air-cooled engine mounted well up out of the dust area, the baler is equipped with four perfectly matched Dayton B-Section V-Belts on a serpentine-type drive. This is a V-Flat drive and the back side of the belts are driven directly on the outside diameter of the Baler flywheel. Clutching action is achieved by a movable idler pulley.

The fifth Dayton V-Belt is a C-Section agricultural belt which drives the Pick Up and Feeder sheave. On the Pick Up and Feeder drive the belt is held under constant tension and is *designed to slip* when feeder or pick-up is overloaded. Clutching action here is accomplished by means of a back side idler.

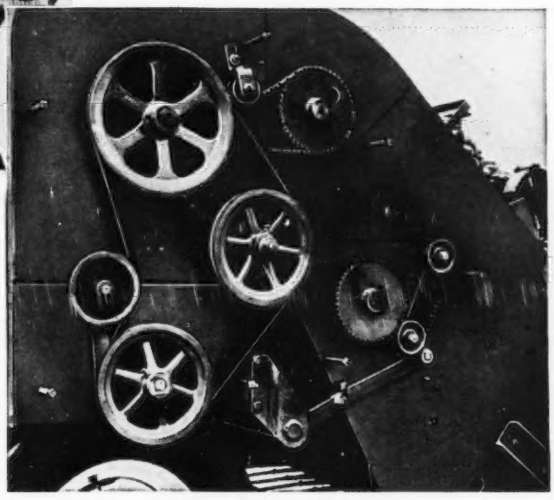
In each instance, drives require double duty, front and back, from the V-Belts delivering the power. To gain this greater power and insure long, economical operation, the New Holland Machine Co. selected Dayton V-Belts to do the job. Performance by the Super "77" has proved the wisdom of that selection over and over again.



Main Drive Assures Maximum Power

Four Dayton B-Section V-Belts transmit the power developed by this new four cylinder VF-4, 24 horsepower, air-cooled engine, to the Full-Floating Pick Up Suspension. Operating over a serpentine-type drive such as this requires great tenacity and gripping power, which these rugged, perfectly matched Dayton V-Belts supply with ease. This is a V-Flat drive with the back side of the belts driving directly on the outside diameter of the baler flywheel. Clutching action is achieved by means of a movable idler pulley.

Dayton V-Belts' unique construction absorbs the shocks of suddenly applied power through seating action in the pulley grooves. This assures smoother starting and running and eliminates vibration. Unaffected by dust or moisture-laden atmosphere, Dayton V-Belts are the perfect answer to main drive applications.



Speed baling pays big dividends

Baling at the rate of 8 bales per minute with the new Super "77" has many dollar and cents advantages. Owners can make the most of ideal baling weather, get the job done faster and pay for the new baler out of proceeds from custom baling on neighboring farms. Because the stronger, harder-gripping Dayton V-Belts on the main drive transmit every ounce of power developed, maximum baling capacity is obtained at minimum cost. Too, because the Dayton V-Belt on the Feeder Drive does permit slippage, more expensive metal parts are saved from costly overload wear and breakage. Also, Dayton V-Belts' longer service life means lower, less frequent replacement cost throughout the life of the baler.

You, too, can do as New Holland Machine Co. has done —place your V-Power requirements with Dayton Rubber Co. for complete satisfaction on any V-power drive. Just write to Dayton Rubber Co., Agricultural O.E.M. Division, Dept. 404, 1500 S. Western Ave., Chicago, Illinois.

Feeder and Pickup Drive

Lifeline of the Full-Floating Pick-Up that gives New Holland's Super "77" its sensational performance record is this sturdy C-Section Dayton V-Belt. Held under constant tension, this powerful Dayton Agricultural V-Belt is so designed that it will permit slippage in the event of overload on the feeder or pick up, thus saving undue wear on costly metal moving parts. Clutching action is accomplished by means of engaging or disengaging a back side idler. The inherent characteristics of this Dayton V-Belt make it ideally suited to give peak performance on this tough farm drive.

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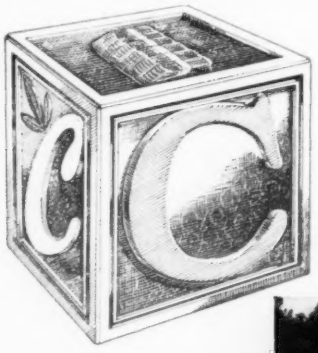
Dayton Rubber

Since 1905

First in Agricultural V-Belts

Agricultural Sales Engineers in Chicago, Moline, New York, San Francisco, Cincinnati and St. Louis



. . . is for COTTON

HISTORY books bear out the fact, all right—old King Cotton has had his share of ups and downs.

But let all take notice, here and now—the sturdy old throne still stands unbroken, and His Venerable Majesty still reigns supreme. In fact, the talk around the kingdom has it that the old boy has recently added another setting to that royal crown of his.

Of course, those who are close to the matter know just what's behind such talk. They know it all started with the introduction of the new John Deere No. 1 Cotton Picker, an efficient, one-row, mounted picker that means speedier picking, extra bales, and bigger savings in time and money—that permits one man to pick up to an acre an hour.

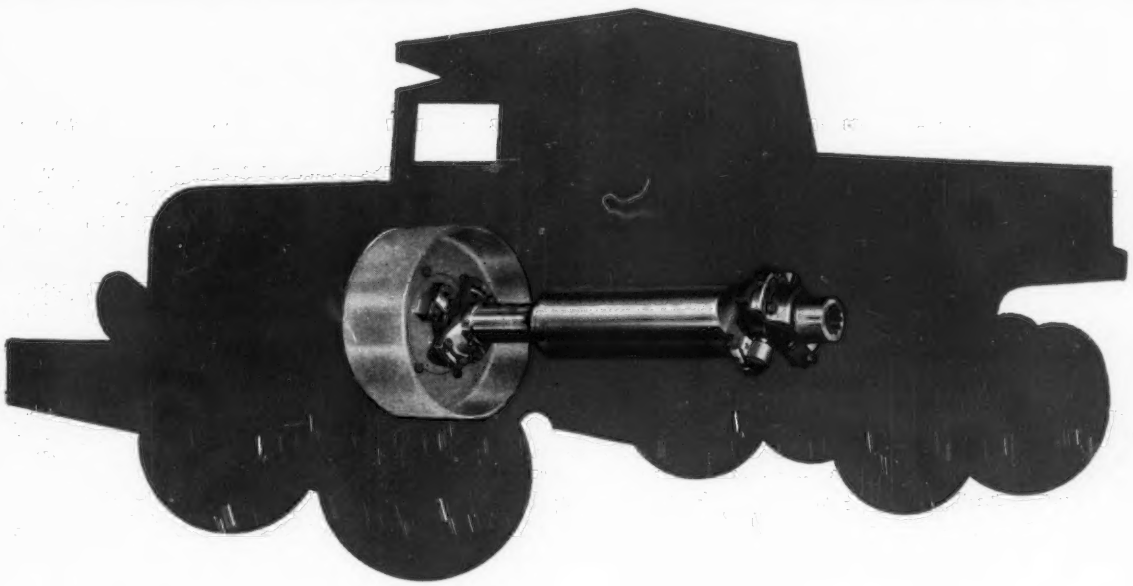
No wonder it's the talk of the countryside—like the big-capacity John Deere No. 8 Two-Row Self-Propelled, the new No. 1 is already proving its right to peerage in a line of quality farm equipment long favored throughout the cotton kingdom.

Long live King Cotton!

JOHN DEERE • Moline, Illinois

Quality Farm Equipment Since 1837

RUGGED



Because MECHANICS Roller Bearing UNIVERSAL JOINTS drive through KEYS—instead of bolts—they stand up under punishment that shears off other types of fasteners. They are designed with less parts and connections for easy assembly and servicing — smooth running balance — maximum strength with less weight — and long, trouble-free, safe operation. Rugged stamina is just one of the advantages you get when you specify MECHANICS Roller Bearing UNIVERSAL JOINTS. Let MECHANICS engineers help you design this and other competitive sales features into your product's transmission train.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2046 Harrison Ave., Rockford, Ill.

MECHANICS
Roller Bearing B-W
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

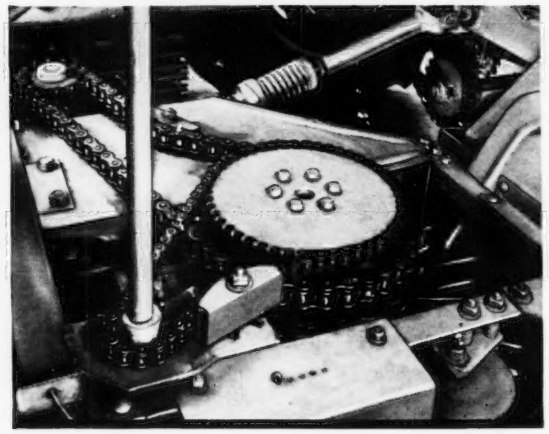
Allis-Chalmers Cotton Picker
equipped with Diamond Roller Chains.

On Allis-Chalmers Modern Cotton Pickers

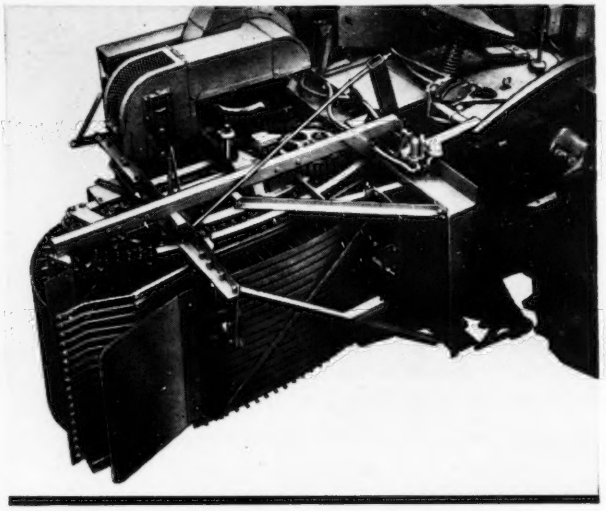
The rotating spindles are major operating parts which are driven by

DIAMOND ROLLER CHAINS

TRADE MARK



Diamond Roller Chain Drives
on one-row model.



Close-up shows Roller Chains that operate picking units.
Chain is in horizontal position.

The one and two row cotton pickers manufactured by Allis-Chalmers, pick, gather, transport and unload the cotton quickly and efficiently. Diamond Roller Chains in spite of heat, dirt, and dust, must perform successfully in the power transfer and operation of the picker's units which gather the cotton.

When such continuous service is required, the long life, reliability and uniform quality of Diamond Chains help to keep output up and operating costs down.

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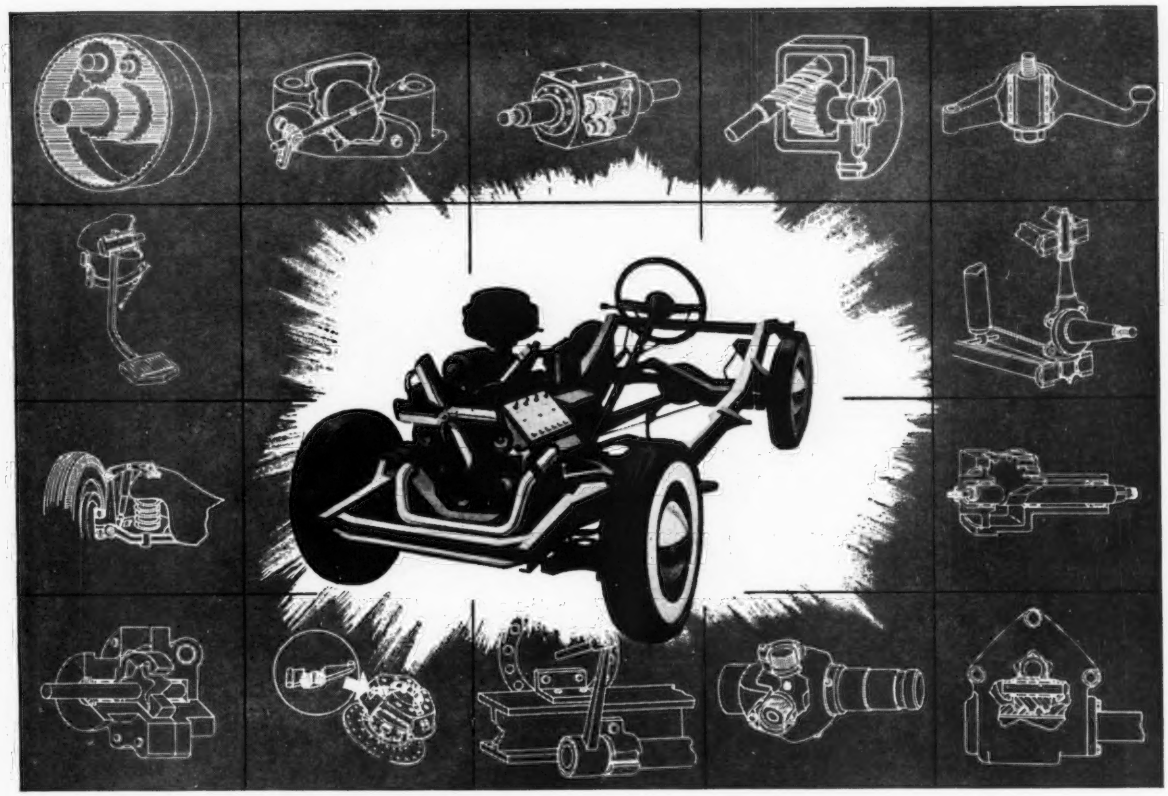
DIAMOND ROLLER CHAINS



TORRINGTON Needle Bearings offer the Automotive Manufacturer these advantages

1. High capacity
2. Small size
3. Low cost
4. Ease of installation
5. Long service life

The automotive industry was one of the first to see the unique advantages of the Torrington Needle Bearing when it was introduced nearly twenty years ago. Today, leading manufacturers of automobiles, trucks and components have standardized on the Needle Bearing to such an extent that it is in use in almost every rotating or oscillating bearing application where compactness, high capacity and ease of installation are important.

The NEEDLE BEARING has been "Performance Proved" in these Major Applications

Universal joints · Governors · Steering gear rollers Steering knuckles · Steering idlers · Power steering Suspensions · Brake camshafts · Brake and clutch linkage pivots · Clutch throw out fingers · Transmissions · Hydraulic pumps · Window lifts *and many others.*

If some of these applications of the Needle Bearing are new to you, why not let our Engineering Department show you how they can improve the design and performance on your product? See your Torrington Bearing representative or write direct.

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TORRINGTON NEEDLE BEARINGS

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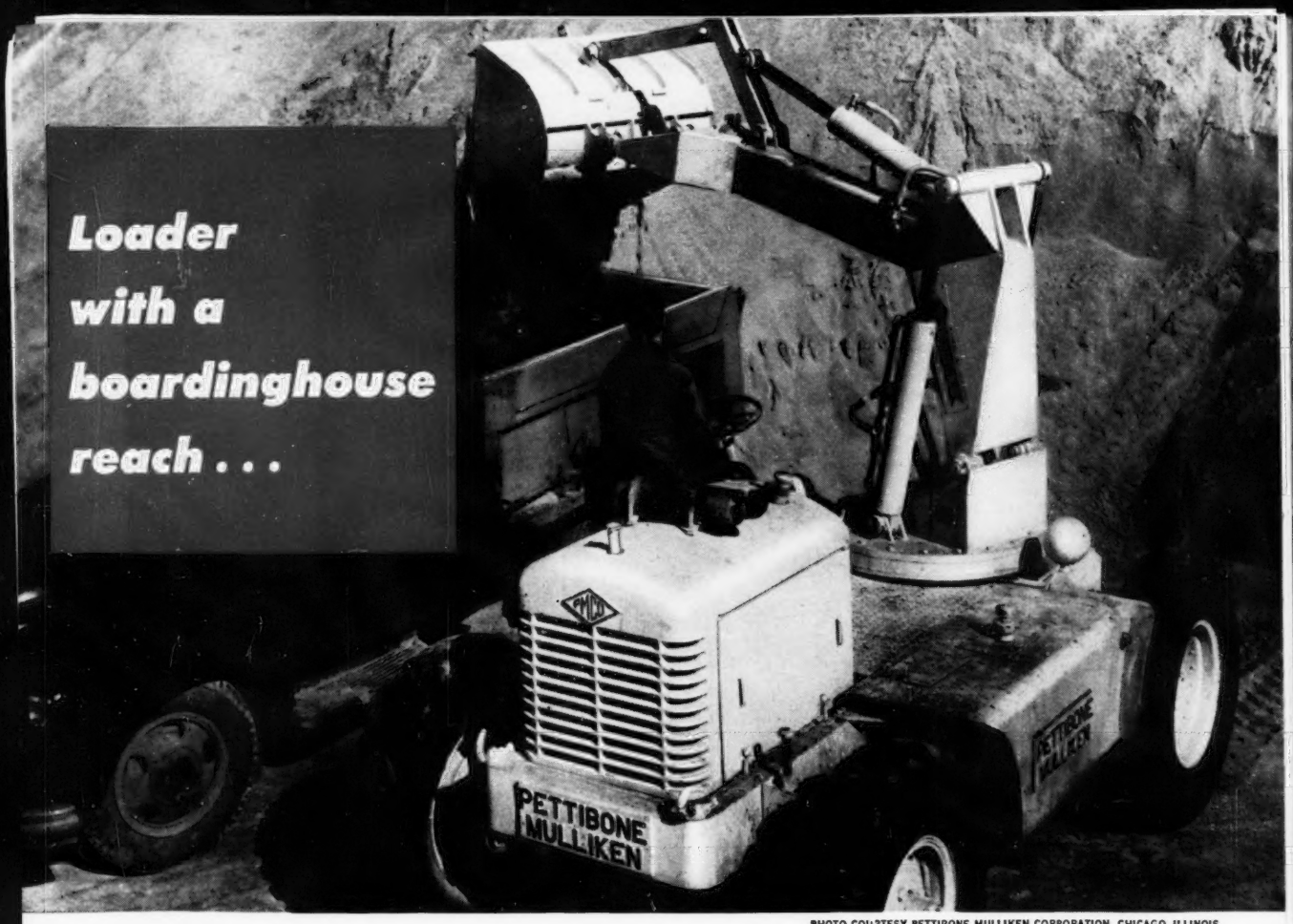


PHOTO COURTESY PETTIBONE MULLIKEN CORPORATION, CHICAGO, ILLINOIS

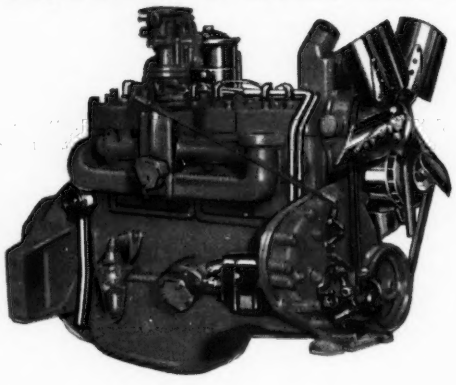
CHRYSLER *Industrial Engine and torque converter assure faster handling of tougher jobs*

This versatile, highly maneuverable loader goes after work like a stevedore after "seconds." Boom swings through 180°, loads faster, in less space, to the left or right without moving from its short, single working line. Cuts loading time up to 25%. Bucket, fork, tote hook and backfiller blade attachments are interchangeable.

Torque Converter provides extra power for tough going, faster acceleration *without* necessity of shifting gears or declutching. Furthermore, the Torque Converter eliminates shock loads to the power train . . . thus reduces maintenance.

Pettibone Mulliken Speed Swing Loaders come in two sizes . . . ¾ cubic yard and 1 cubic yard. Both sizes can be supplied with four-wheel drive (like the unit pictured), and four-wheel steer. Chrysler 230 cubic inches displacement Model 30 Industrial Engine drives the ¾ cubic yard unit, and the 265 cubic inches displacement Model Ind. 16 drives the 1 cubic yard unit. Chrysler Torque Converter connects engine with four-speed transmission, transmits power to boom.

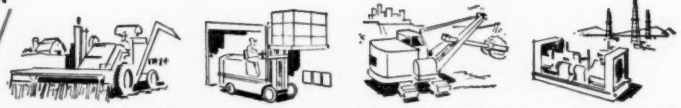
In considering power for your equipment, remember Chrysler Power is not expensive. Production-line methods adapted to specialized industrial engine building provide a custom-built engine at mass-production prices. See a Chrysler Industrial Engine dealer or write: ***Dept. 169, Industrial Engine Division, Chrysler Corporation, Trenton, Mich.***



CHRYSLER *Industrial Engines*

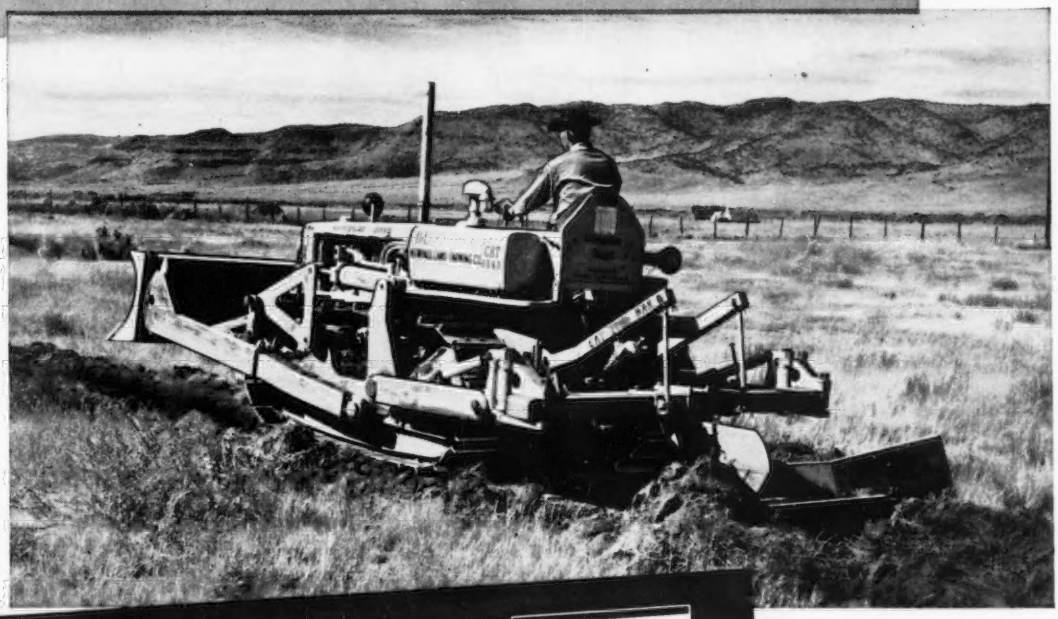
INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

HORSEPOWER WITH A PEDIGREE



AGRICULTURE • INDUSTRY • CONSTRUCTION • OIL FIELDS

"Caterpillar" No. 41 Hydraulic Control imparts increased versatility to "Caterpillar" D2 and D4 Diesel Tractors. Here a D4 Tractor and tool bar with ditcher attachment is making irrigation ditches.

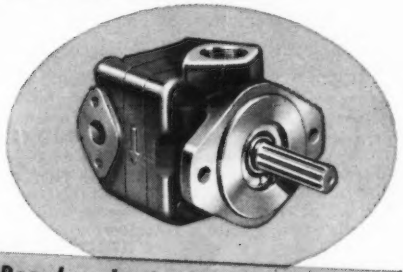


"CATERPILLAR"® uses VICKERS® HYDRAULIC PUMPS

"Caterpillar" selected the Vickers Pump (shown below) for the source of power in the No. 41 Hydraulic Control because of its outstanding performance . . . performance that results from several exclusive features. This Vickers Pump is vane type, hydraulically balanced and has automatic wear compensation. This means that it delivers more oil while taking less power from the engine . . . that it has a much longer life with minimum maintenance . . . and that it insures dependability and easier cold weather starting of the tractor. A Vickers Pump is the mark of high quality in hydraulic power controls.

6980

This is the Vickers Pump used in the "Caterpillar" No. 41 Hydraulic Control. Hydraulic systems on tractors and other farm equipment use more Vickers Pumps than any other make.



People who look for quality in tractors and farm equipment also look for VICKERS®

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DIVISION OF THE SPERRY CORPORATION
1516 OAKMAN BLVD., DETROIT 32, MICH.

Application Engineering Offices: • ATLANTA • CHICAGO AREA (Brookfield) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) PITTSBURGH AREA (Mt. Lebanon) • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

FOUR • • •

COMPLETELY NEW LINES OF HYDRAULIC PUMPS WHICH GIVE YOU FAR MORE IN PERFORMANCE AT FAR LESS IN COST!

- Pumps to give new life to existing equipment . . . to improve performance, increase capacity!
- Pumps that afford the design engineer the basic equipment for entirely new concepts in hydraulically operated machines!
- Pumps for machines to do work better, quicker, cheaper!

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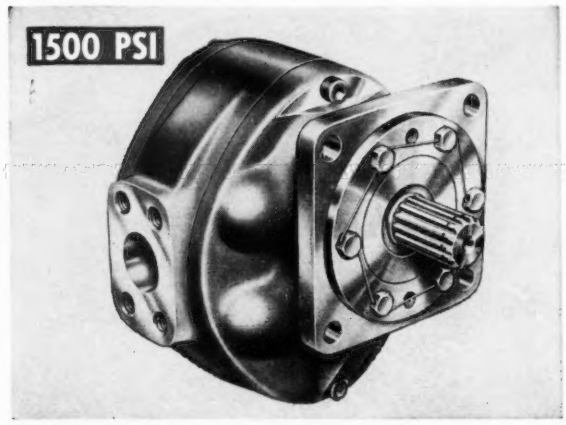
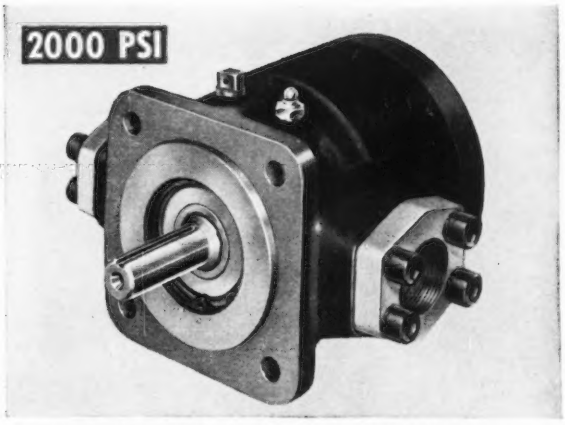
1107 EAST 222nd STREET • CLEVELAND 17 • OHIO



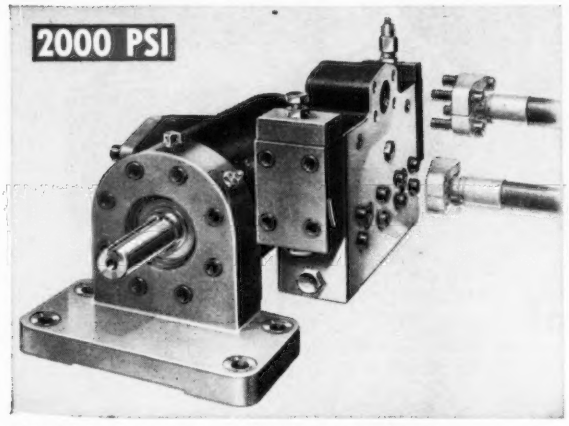
SERIES H GEAR-TYPE PUMPS

The HYDRECO Series H Pumps are intended for use in the hydraulic systems of heavy-duty mobile and industrial equipment, especially where shock loads, impact and rugged service are "normal working conditions". Four sizes (40, 50, 60, 70 gpm) deliver fluid power at 1500 psi . . . increased horsepower gives greater work output. *Pressure-Balanced* wear plates reduce oil slippage and eliminate power-robbing frictional contacts. SAE Flange Mounting and split-flange hose connections make servicing simple and reduce down-time. Equipment is on-the-job longer.



SERIES PF-100 VANE-TYPE PUMPS

DUDCO PF-100 Series Pumps can double the value of your *hydraulic dollar*. You get 2000 psi continuous duty, single-stage construction for the cost of equal capacity low pressure pumps . . . improved equipment design and increased machine efficiency without the payment of premium prices. These Pumps feature a simplified, 3-unit construction . . . the pumping cartridge incorporates the famous DUAL-VANE design which provides and assures complete balance of all hydraulic pressure loads. These Pumps have capacities of 3, 5, 8 and 11 gpm at 1200 rpm.



SERIES PF-100 DOUBLE PUMPS WITH VALVE PANELS

DUDCO PF-100 Series Double Pumps with Valve Panels are versatile units unmatched as a source of *Controlled Fluid Power* for a wide variety of modern industrial equipment . . . for 2000 psi operation of circuits calling for a substantial variation in pump volume as during "close and hold" or "traverse and feed" cycles. The Valve Panel contains the valving necessary for pressure regulation and flow control . . . the external part of a system will have less valves and controls, reduced piping and fewer parts to maintain. Ten capacity combinations with either automatic or remotely controlled operation.

SERIES PV-600 PISTON-TYPE PUMPS

DUDCO PV-600 Series Variable Delivery Pumps generate continuous duty pressures up to 5000 psi. Two types of controls match pump output to system demands. A pressure-compensated regulator automatically varies the volume in response to system pressure. A hand wheel control enables an operator to vary the volume during the machine cycle. High pressure variable delivery means power is transmitted without the necessity for an accumulator and without any wastage of power thru a relief valve.

WRITE TODAY . . .

Get full particulars on these important new developments in hydraulic pumps!

The New York Air Brake Company
1107 East 222nd Street
Cleveland 17, Ohio

Please send details on

- ☐ SERIES PF-100 VANE-TYPE PUMPS
- ☐ SERIES H GEAR-TYPE PUMPS
- ☐ SERIES PF-100 DOUBLE PUMPS WITH VALVE PANELS
- ☐ SERIES PV-600 PISTON-TYPE PUMPS

Name_____

Address_____

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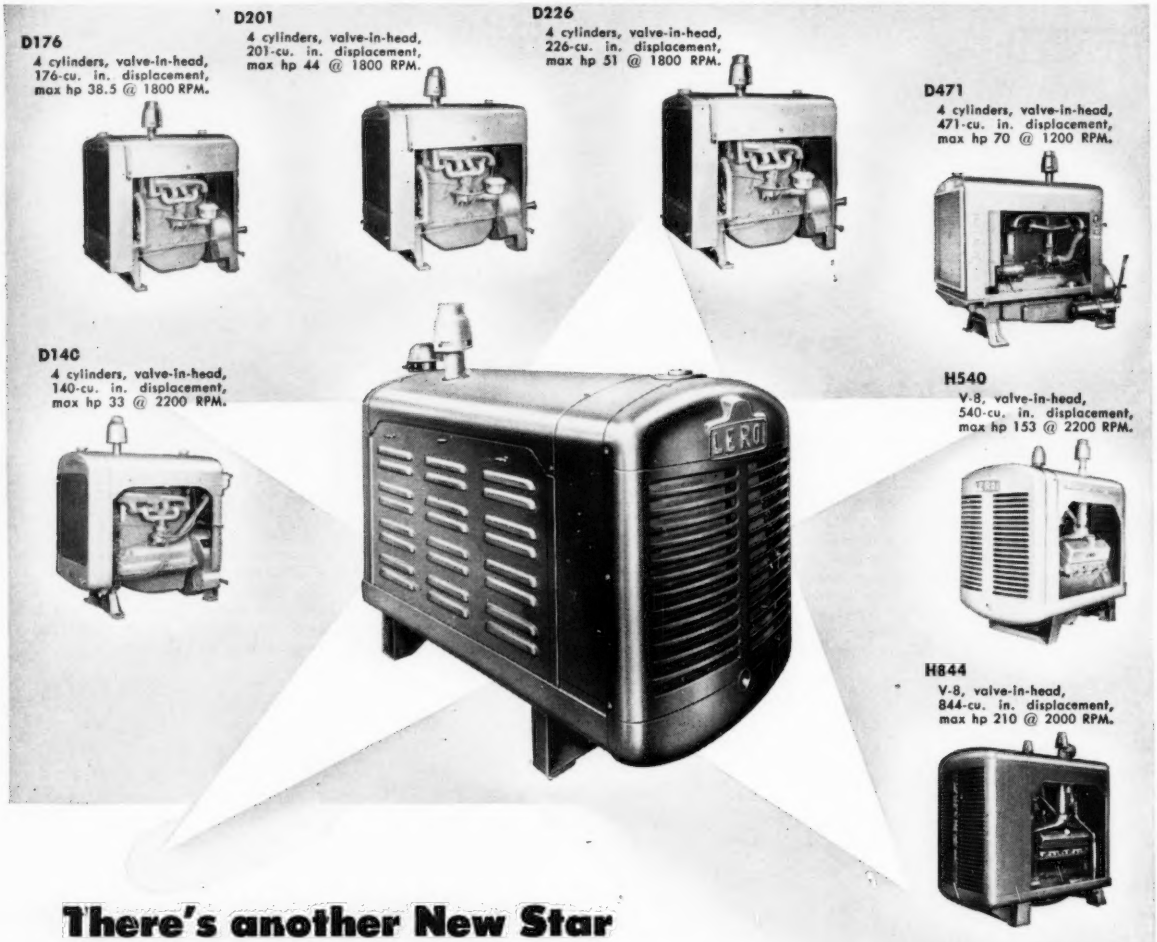
D176
4 cylinders, valve-in-head, 176-cu. in. displacement, max hp 38.5 @ 1800 RPM.
D201
4 cylinders, valve-in-head, 201-cu. in. displacement, max hp 44 @ 1800 RPM.
D226
4 cylinders, valve-in-head, 226-cu. in. displacement, max hp 51 @ 1800 RPM.
D471
4 cylinders, valve-in-head, 471-cu. in. displacement, max hp 70 @ 1200 RPM.
D140
4 cylinders, valve-in-head, 140-cu. in. displacement, max hp 33 @ 2200 RPM.
LE ROI
H540
V-8, valve-in-head, 540-cu. in. displacement, max hp 153 @ 2200 RPM.
H844
V-8, valve-in-head, 844-cu. in. displacement, max hp 210 @ 2000 RPM.

There's another New Star in the Le Roi Power Lineup!

The F330 330 cu. in.

...a valve-in-head, six-cylinder, heavy-duty engine designed to give you economical, dependable, 107 hp at 2500 rpm

Here it is, Le Roi's new 330-cu. in. engine, the F330.

Like all Le Roi heavy-duty engines, it has overhead valves to provide maximum performance and the utmost economy.

Also, the F330 has all the features that have been standard in Le Roi engines for many years — features like removable wet-cylinder sleeves that keep maintenance costs down and add greatly to the operating life of this magnificent new engine.

But most important to you, here's a compact engine that is easy to install . . . an engine that's power-packed to provide the kind of peak performance that lends prestige to any piece of equipment in which it is used.

If you need a 330-cu. in. engine — and if you need the last word in modern engine design, you need this new Le Roi F330. It operates on gasoline, natural gas, or butane. For all the facts, write for our new bulletin.

LE ROI

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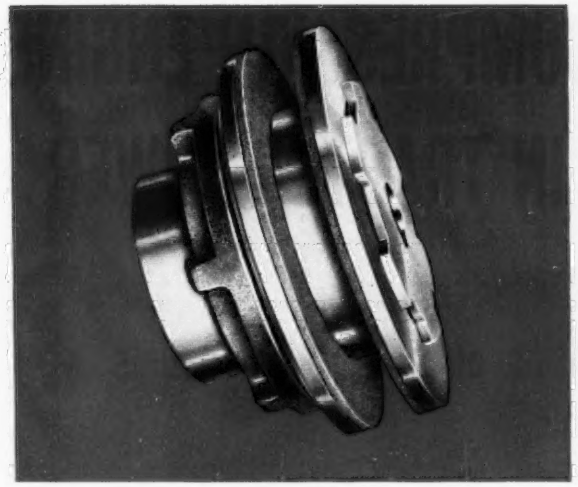
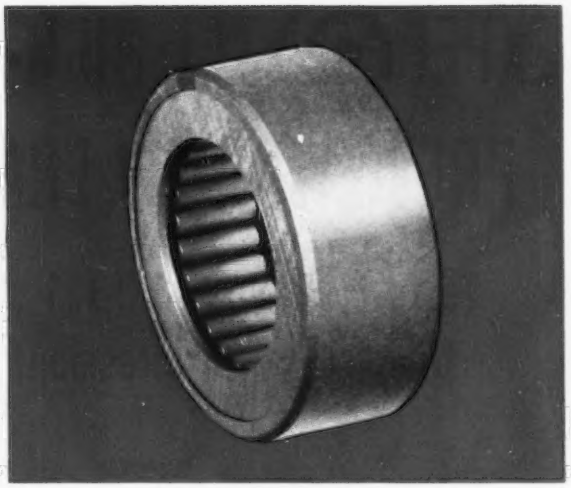


Torque Limiter



200-Series Cam Clutch

NOW! Two new MORSE products to solve design and maintenance problems

1. New Morse Torque Limiter

Eliminate the inconvenience, expense and machine downtime connected with resetting shear-pin mechanisms. The Morse Torque Limiter is torque-sensitive, compact and tamperproof.

Torque adjustable and adaptable, the Morse Torque Limiter can be used with sprockets, gears or pulleys. It gives positive protection on machine drives and automatically slips at overload setting and resets when overload condition is corrected.

The Torque Limiter is available from stock in diameters from 3″ to 10″; maximum ratings from 20 through 628 ft.-lbs.

2. New 200-Series Cam Clutch

The simplicity of design, ease of installation and maintenance make Morse 200-Series Cam Clutches as adaptable as bearings for indexing, over-running and backstop applications.

Ground to same outside diameters as 200-series bearings, they will fit housings bored to accommodate these common bearing sizes.

The Morse 200-Series Cam Clutch combines maximum torque capacity with minimum space requirement. It is a self-contained assembly, furnished without inner races; can be mounted directly on shafting. Clutches are furnished pre-lubricated, ready for immediate installation.

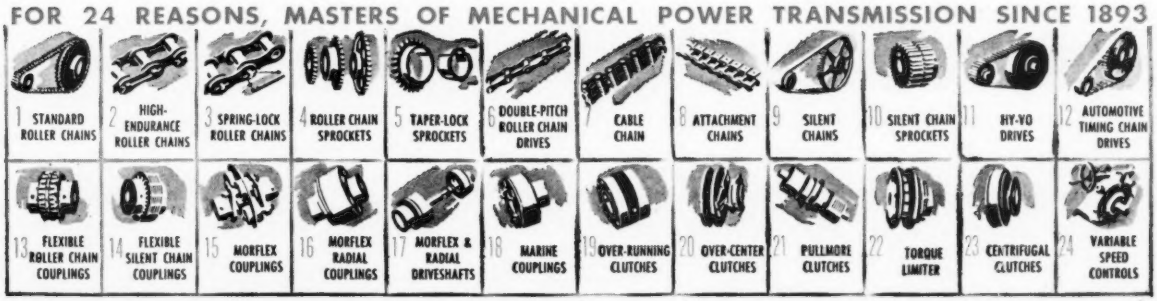
Get more details. For information on Morse Torque Limiter, write today for Catalog C 14-54. For information on 200-Series Cam Clutch, ask for Catalog C 12-54. **Morse Chain Company, 7601 Central Avenue, Detroit 10, Michigan.**

MORSE

PRODUCTS OF B-W BORG-WARNER

MECHANICAL POWER TRANSMISSION PRODUCTS

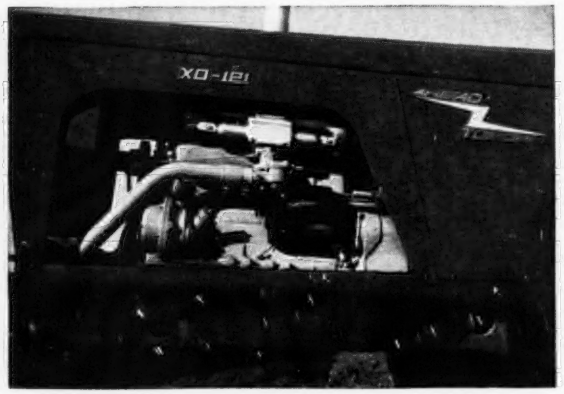
FOR 24 REASONS, MASTERS OF MECHANICAL POWER TRANSMISSION SINCE 1893



EXPERIMENTAL HIGH-COMPRESSION ENGINE PREVIEWS NEW ERA IN TRACTOR POWER

Tests on Oliver's XO-121 show advantages to be gained from higher-compression ratios and high-octane fuels

The approach taken by the Oliver Corporation in the development of their new XO-121 experimental tractor engine shows promise of becoming the yardstick for a new stand-



XO-121 engine mounted in an Oliver "88" chassis for testing and display purposes.

ard in farm power. Although it was built purely as a research tool and will never be put into production, its design is sure to have a marked effect on the development of future tractor engines.

What is the secret of the engine's outstanding performance? The secret lies in a high-compression ratio of 12 to 1 that makes the XO-121 the most efficient tractor engine ever built.

Developing the fuel that would take advantage of the engine's extra-high-compression ratio posed a problem. So Oliver engineers turned to Ethyl Corporation for assistance because of Ethyl's wide experience with gasoline engines and experimental fuels.

Ethyl "custom-built" a gasoline for the engine. This special gasoline is by no means a trick or synthetic fuel, however. It is a blend of commercially available high-octane components plus "Ethyl" antiknock compound.

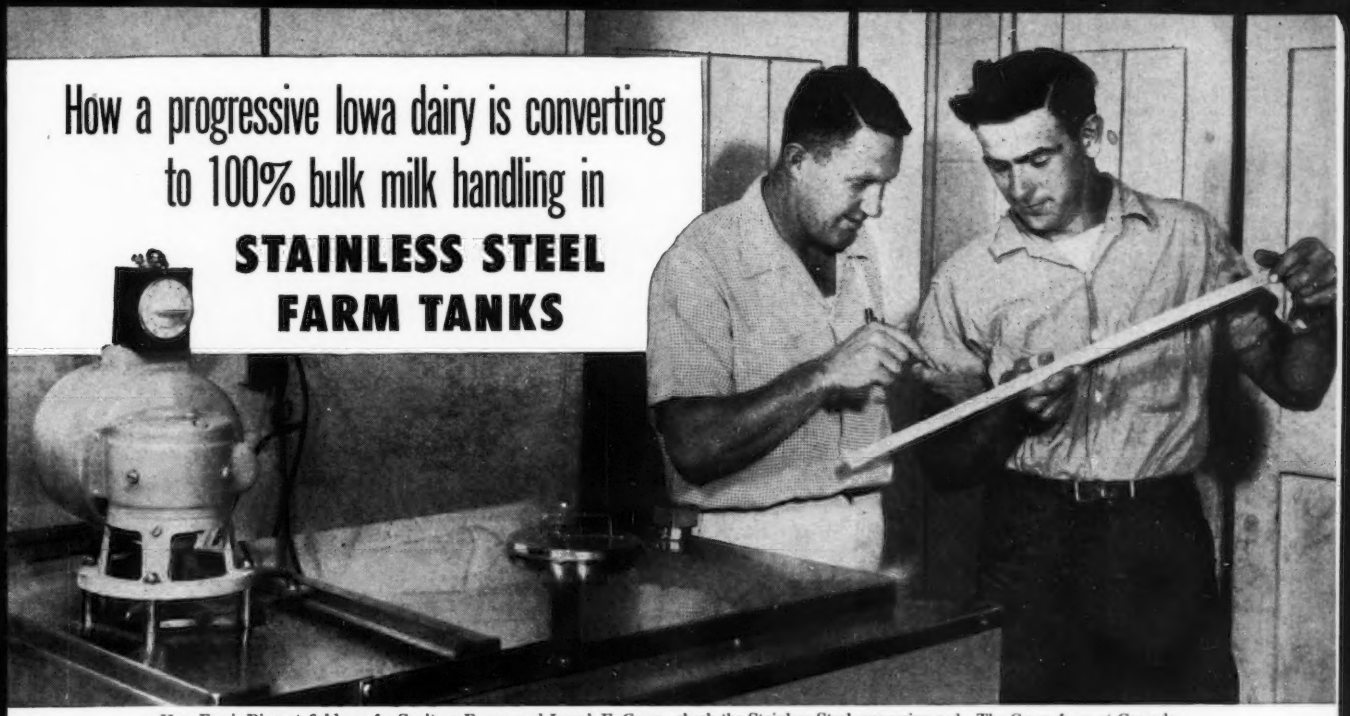
The XO-121 is one step in a program to improve farm-tractor performance. It leaves little doubt about the value of a well-designed, high-compression engine that can

Field tests to determine power output and fuel economy.

take full advantage of improved gasolines. The knowledge gained will mean better performance and greater economy in tomorrow's farm tractors.

ETHYL CORPORATION
New York 17, N. Y.

How a progressive Iowa dairy is converting to 100% bulk milk handling in STAINLESS STEEL FARM TANKS



Here Farris Biggart, fieldman for Sanitary Farms, and Joseph E. Green, check the Stainless Steel measuring rod. The Green farm at Cascade, Iowa, is one of the Sanitary Farms Dairy's producers that has converted to the bulk milk handling system.

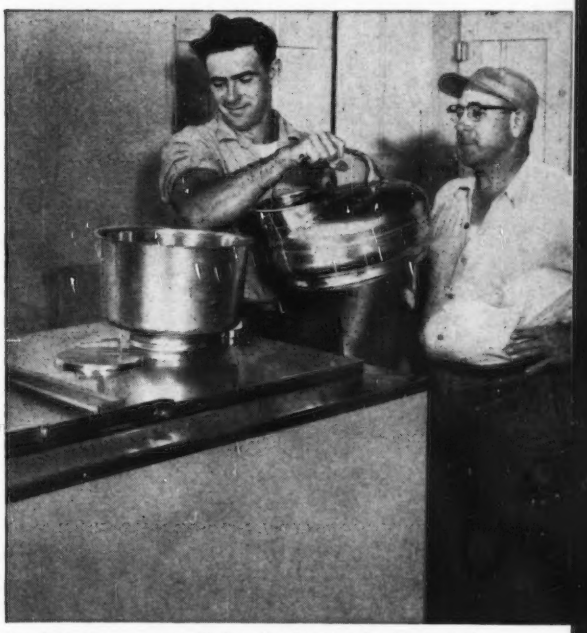
IN August, 1953, Sanitary Farms Dairy, Cedar Rapids, Iowa, launched a program that will eventually see every one of its 340 producers equipped with a Stainless Steel farm tank for bulk handling of milk.

Conversion is going ahead a route at a time and the job will be completed in about a year. Much of the success of the program to date is the result of a careful explanation of the advantages of the bulk handling system to producers by Farris Biggart, Sanitary Farms fieldman.

Mr. Biggart points out that Stainless Steel farm tanks mean a gain of 10 to 30 pounds of milk every pick-up, plus a slight rise in butterfat content. "We find," he says, "a producer is more willing to cooperate when he understands that the bulk handling system means bigger milk checks through increased weight, less heavy hand labor, better quality and great savings in time."

Sanitary Farms Dairy is helping its producers make the change by finding a market for equipment made obsolete by the change to bulk handling. New Stainless Steel tanks are being made available to the producers on a contract basis.

If you would like more information on the bulk handling system, mail the coupon below. Working with our customers who fabricate farm tanks from USS Stainless Steel, we have accumulated much data on the bulk milk handling system. We will be happy to make it available to you.



Joseph E. Green pours milk into the Stainless Steel farm tank while his father, Joseph A. Green, looks on.

Agricultural Extension Section
United States Steel Corporation, Room 4446
525 William Penn Place, Pittsburgh 30, Pa.

Please send me free literature about farm bulk milk equipment. Send information to:

Name.....

Title.....

Company.....

Street.....

City.....Postal Zone.....State.....

United States Steel is a steel producer, not a bulk milk equipment fabricator. Your request, therefore, will be sent to manufacturers who fabricate bulk milk equipment for farm use.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
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USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

4-830-A

UNITED STATES STEEL

New Holland Model 66 Twine-Tie Baler on the job. Close-up shows two BCA Idler Pulleys used in pick-up chain idler assembly; cut-away above shows construction of BCA Idler Pulley.

BCA

IDLER PULLEY ASSEMBLIES

simplify installation and service on New Holland Model 66 Twine-Tie Balers

The BCA Idler Pulley combines a bearing and a pulley in a pre-lubricated package *unit* effectively sealed against dust and grit. This simplifies the assembly problems of the manufacturer of farm equipment. And, because the bearing is sealed effectively to keep dirt out and grease in, the farmer has no field-servicing problems.

On New Holland Model 66 Twine-Tie Balers, BCA Idler Pulley assemblies are used as a chain idler that guides the drive chain around the pick-up drive sprocket, and as return pivots for the drive chains in both the wadboard and plunger assemblies.

BCA Idler Pulley assemblies are adaptable to many agricultural applications: combines, hay balers, forage harvesters, grain elevators, corn and cotton pickers, spreaders. Sheave design can be varied for use in chains, flat belts, or v-belts. These versatile assemblies are typical of the developments that result when equipment manufacturers take advantage of BCA engineering cooperation and design assistance in solving problems involving ball bearings. When you have such a problem, bring it to us.

BCA

BEARINGS COMPANY OF AMERICA

DIVISION OF FEDERAL-MOGUL CORPORATION

LANCASTER • PENNSYLVANIA

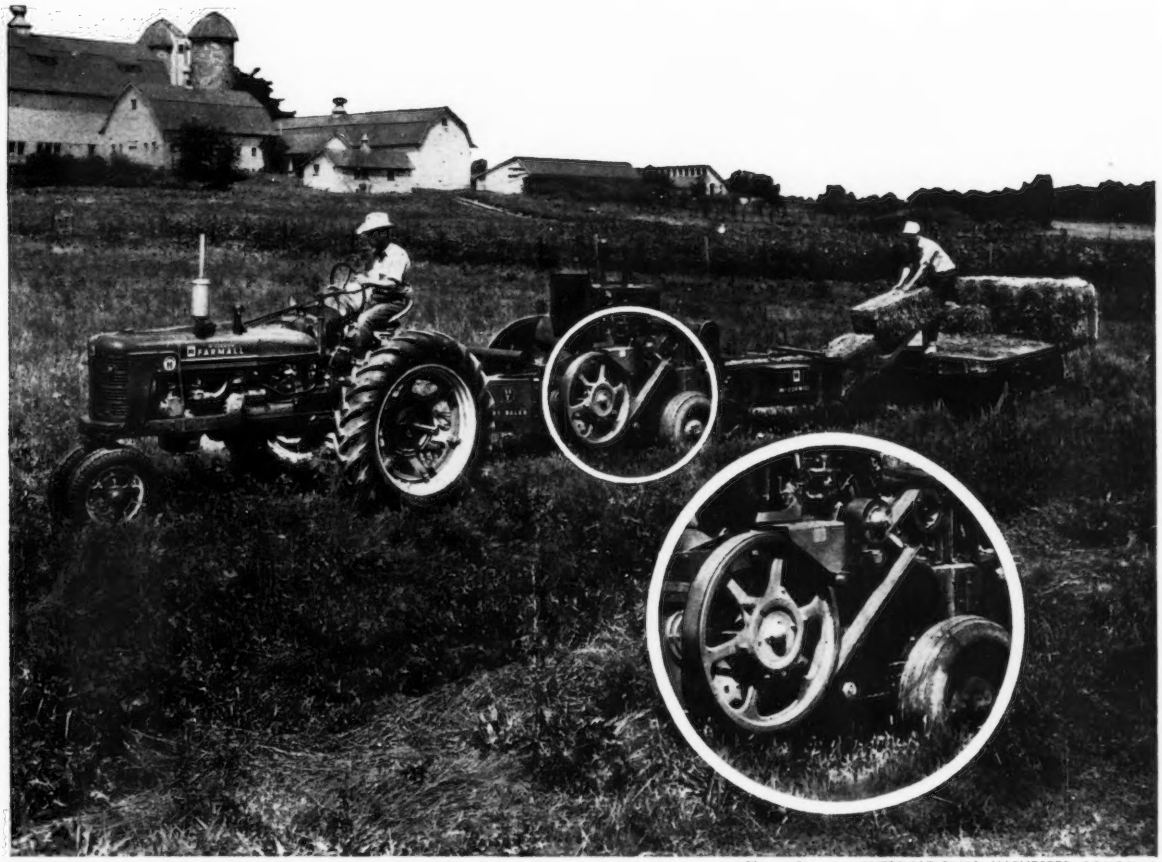


Photo Courtesy INTERNATIONAL HARVESTER COMPANY

MANHATTAN AGRICULTURAL BELTING

more dependable . . . more use per dollar

On all types of power applications the engineered features of Manhattan Agricultural Belts have earned the confidence of Farm Equipment Manufacturers. The strength, flexibility and long-life of these belts assure uniform performance and day-in, day-out dependability . . . "More Use per Dollar" where it counts most — on the job.

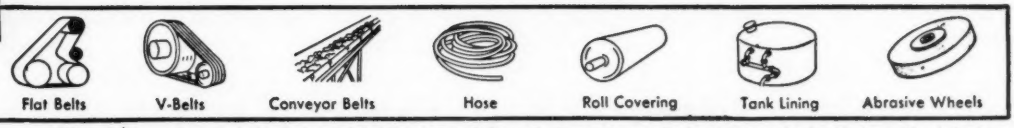
Manhattan Agricultural V-Belts, Poly-V Drives, and Condor Whipcord Endless Belts are designed to meet the most rigid specifications of modern farm machinery. Manhattan works closely with equipment manufacturers' engineers to improve machine efficiency through the design of belt transmission drives as nearly foolproof and trouble-free as possible.

Manhattan is ready and eager to work with your engineers to determine the proper belt for your equipment needs. Call on us at any time to discuss your belting problems.

R/M

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Bowling Balls. RM-441

6

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and the finest engineering and

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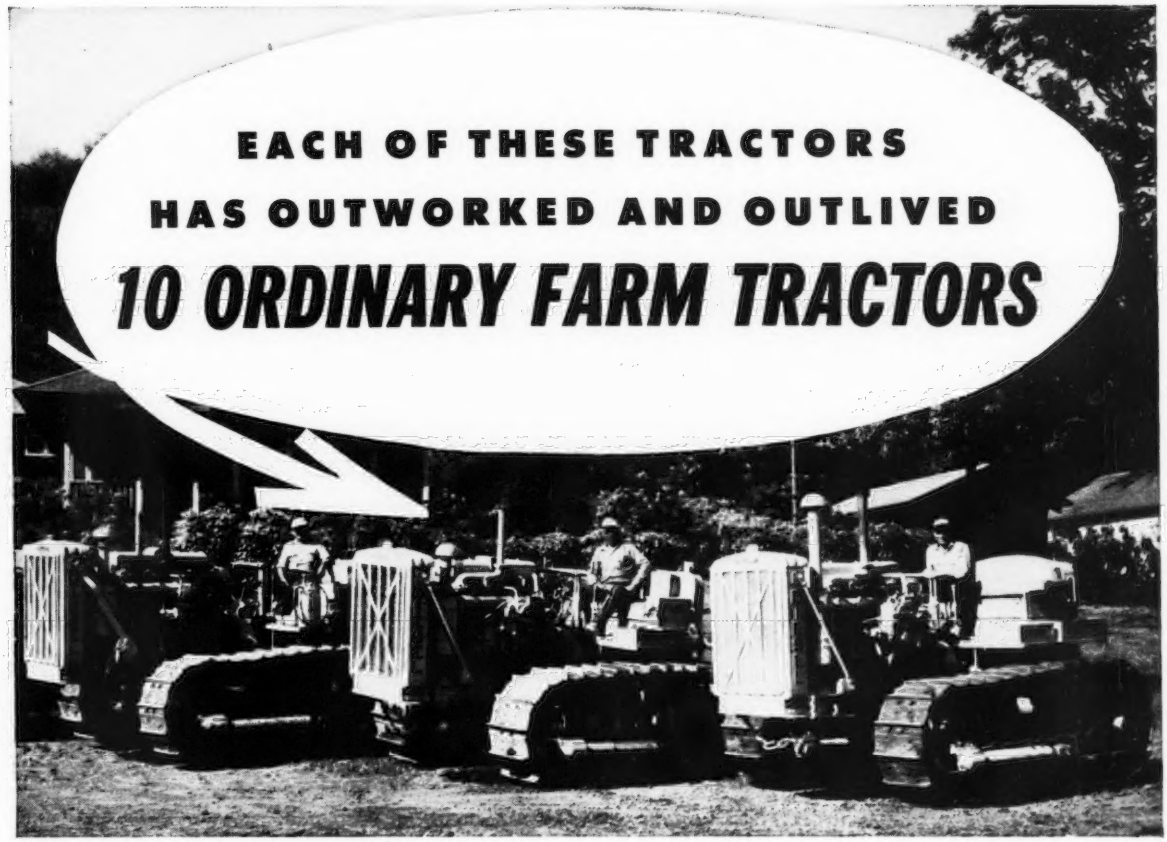
DIVISION OF CLEVITE CORPORATION



In the illustration above, the three Caterpillar Diesel Tractors have worked in the field for about 290,000 hours, or an average of nearly 100,000 hours apiece. To accumulate these records, they have, on many occasions, worked day and night for the past 18 years, subsoiling, pulling plows, or hauling cane cars over narrow gauge railway.

As you know, very few ordinary tractors last more than 8,000 meter hours . . . or 12-15 years. Or, compare these tractors with 100,000 work hours, to your automobile. At 30 m.p.h. you would have to drive it 3 *million miles* to equal this record! Yet, scores of CAT* Diesel Tractors have worked for 50,000, even 80,000 hours. No other tractor has ever come close to these records!

Why do Caterpillar Diesel Tractors last so long? They're *built* to take punishment. The finest research, design and production see to that. *Next,* parts are always available to keep Caterpillar track-type Tractors at work. *Third,* Caterpillar's policy of continous improvement instead of annual model changes makes many replacement parts even longer lived than the original parts.

Caterpillar Tractor Co., Peoria, Ill., U.S.A.

Keith S. Tester, manager of the Lihue plantation, Hawaii, reports about the three Caterpillar Diesel Tractors shown here: "We believe the record speaks for itself. This plantation has been a consistent user of Caterpillar-built equipment since 1911."

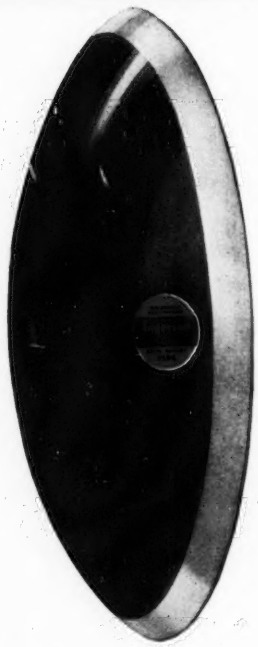
CATERPILLAR*

*Both Cat and Caterpillar are registered trademarks — ®

DIESEL FARM TRACTORS
TOOL BARS • IMPLEMENTS

J. I. Case "VAC-14" Tractor pulling "EDHA" Pivoting Disc Harrow equipped with Ingersoll Discs.

are SHOCK-PROOFED to stand up in the field



When the going gets rough, the discs must be tough. That's why you find so many leading tillage implements coming through equipped with Ingersoll discs.

Ingersoll discs are tougher than tough—because they're *shock-proofed* from start to finish. The super-tough steel—Ingersoll's own Tem-Cross® steel—is cross rolled to prevent splitting and curling. The discs are specially heat treated for greater uniformity, for maximum resistance to stress and strain, and to prevent warping. Ingersoll's exclusive *long draw* process gives them just the right degree of hardness for maximum resistance to abrasion and wear, and to the shock and strain of hard field use.

That adds up to longer life, dependability, *extra acres of work.* That's what *your* customers want. And that's why it pays to recommend Ingersoll discs—for new equipment and replacement use.

Other Agricultural Products:

Spring Teeth for Harrows and Cultivators

•

Coil Spring Shanks

ENGINEERING B-W PRODUCTION

INGERSOLL PRODUCTS DIVISION

Borg-Warner Corporation

310 S. Michigan Avenue • Chicago 4, Illinois

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Ingersoll

HEAT TREATED DISCS

AGRICULTURAL ENGINEERING

VOL. 35 SEPTEMBER, 1954 NO. 9

Experimental Stress Analysis

Its Application as a Tool for Solving Agricultural Engineering Problems

James K. Jensen

NEW tools for the solution of engineering problems are constantly being developed and accepted for widespread use in industry. Educational institutions have a responsibility to keep their curriculums modern to the extent that their graduates are at least familiar with the more important new developments. However, students and staff alike are protesting that their courses are already full. Additional subjects cannot be taught unless the length of time for an engineering education is extended.

The addition of new methods of investigation to the facilities of product engineers in industry does not of itself add to the burden of engineering work. Quite the contrary, any new tool which does not simplify and reduce the task of providing sound, functional, competitive designs has no place in industry. Engineering college laboratory experiments are at least analogous to industrial development work. Therefore, if these new methods reduce work in industry, couldn't they be used in colleges in similar ways, thereby introducing them to the students without additional crowding of an already full course of study?

One such tool that has become increasingly important during the past 15 years is "experimental stress analysis." Stress analysis as a study of the effect of loads on structures is as old as engineering. However, like many basic concepts in any field of knowledge, the details of practical application get so complex that theory alone cannot supply the required answers. Experimental stress analysis has proved to be a means for obtaining exact quantitative information about distribution of loads in structures and behavior of materials under these loads. Photoelasticity is one of the older experimental techniques which has been used primarily in institutional work in the nature of pure research. The use of brittle lacquer to indicate stress patterns is a more recent development which in our experience is most useful to give qualitative information. It is through the use of the electric-resistance strain gage that experimental stress analysis has reached its present degree of versatility and usefulness. A description of the way in which we have used strain gages in providing basic product design information and to develop these designs may suggest some similar uses in engineering college laboratories.

Electric-resistance strain gages, marketed in this country under the trade name SR-4 by the Baldwin-Lima-Hamilton Corp., have received sufficient publicity during the past five years that most engineers are familiar with their principles. For the benefit of any excluded by that statement, a strain gage is a grid of very small diameter wire bonded to a surface so that the wire is strained in the same amount as the outer fibers of the specimen. The resulting deformation of the wire produces a proportional resistance change which can be measured electrically. Over-all accuracy of strain measurement may be as good as $\pm 1/4$ percent.

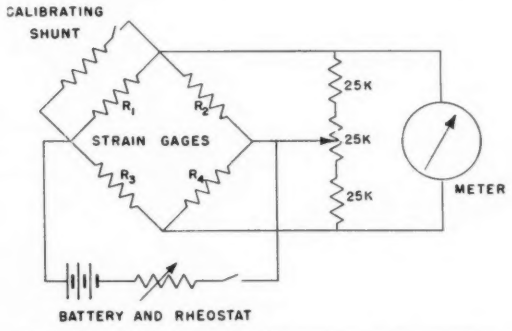

Fig. 1 Basic d-c bridge circuit for strain-gage measurements

While the fundamental use of strain gages is to measure the stress in a structural member under an operating load, there are modifications of this use which better illustrate the principles of measurement.

The basic Wheatstone bridge circuit for strain-gage measurements is shown in Fig. 1. We use some modification of this circuit for all of our field and laboratory work. The four arms of the bridge may be 1 to 4 strain gages, designated in the drawing as R_1, R_2, R_3, and R_4. If less than four gages are used, the bridge may be completed with precision wire wound resistors. The bridge is energized with a battery connected through a switch and rheostat to control the current. The balancing network consists of 25,000-ohm resistors on either side of a 25,000-ohm potentiometer. These values are not critical; higher resistance values will give more precise control; lower values will give an extended balancing range. The calibrating shunt across one arm of the bridge is of such a value that the equivalent parallel resistance of the shunted arm gives a bridge unbalance approximately equal to the unbalance expected due to strain. This shunt calibration resistance provides a means of standardizing the battery current and determining the

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Acknowledgment: The author acknowledges the work of many members of the engineering research and product engineering divisions of the John Deere Waterloo Tractor Works who assisted in the development of these techniques of measurement. Particular appreciation is due W. H. Worthington, who sponsored the development of these techniques to obtain data for his continuing investigation of farm tractor dynamics.

sensitivity of the indicator. The indicator may be a simple d-c microammeter, a galvanometer, or a cathode-ray oscilloscope. The type of indicator chosen depends upon the circuit constants and the type of measurement — static or dynamic — being made.

Let us examine briefly the circuit constants to understand better the magnitude of the quantities with which we are dealing. For the circuit in Fig. 1 consisting of four gages, two in tension and two in compression, the current at the indicator is given by the expression:

$$I_M = I_B \times GF \times e \times R/(R + R_M)$$

where I_M = meter current, amperes
I_B = current from battery, amperes
GF = gage factor, the proportionality constant between percent resistance change in the gage and percent elongation of the strained part. (The value of this constant is supplied by the gage manufacturer.)
e = strain, inches per inch
R = gage resistance, ohms
R_M = terminal resistance of meter, ohms.

This equation neglects the small amount of current flowing in the balancing network.

Using typical values of 0.090 amp for battery current, which is the current from a 45-v radio "B" battery supplying a 500-ohm bridge, strain of 0.0015 in per in (45,000 psi stress in steel), 500-ohm strain gages with a 3.4 gage factor, and a meter having a resistance of 1000 ohms, the current through the meter will be 153 microamperes. This is more than enough output to give full-scale reading on a 100-microampere panel meter costing $10.

Where the output of the bridge is determined by a high input impedance voltage measuring device such as an oscilloscope, the bridge output voltage is given by the term:

$$E = E_B \times GF \times e$$

where E = bridge output voltage, volts
E_B = battery voltage, volts.

Using constants from the preceding example, the bridge output voltage would be 0.23 v, well within the range of a popular $300 oscilloscope having a maximum vertical deflection sensitivity of 0.01 v per in.

In the preceding circuit, the calculated output is based on four active gages, two in tension and two in compression. Gages strained in the same direction are on opposite legs of the bridge and adjacent to gages strained in the opposite direction. This arrangement makes the most effective use of the gages and battery and provides compensation for temperature variations. If only two gages are active, the output will be one-half that previously calculated, and if one gage is active, the output will be one-fourth. In any case, temperature compensation requires that each active gage be adjacent to an identical gage, whether or not it is active.

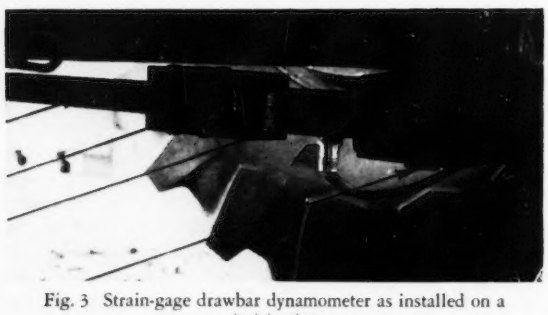

Fig. 3 Strain-gage drawbar dynamometer as installed on a test tractor

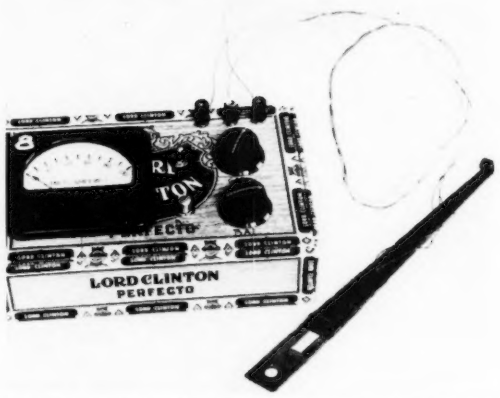

Fig. 2 A simple, complete strain-gage transducer and indicator

Any physical phenomenon that can be applied to a strain member to result in tension in one part of the member and compression in another can be measured with this circuit. By exercise of some thought and ingenuity, many physical measurements may be made more easily and cheaply by this method than by older methods.

As an example of the simplicity of this system, all the elements are contained in the cigar box and flat spring

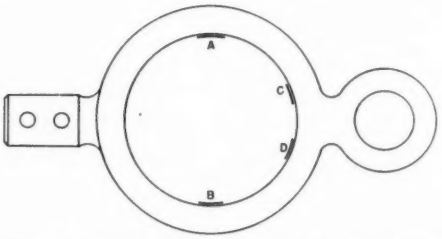

Fig 4 Detail of sensing element of drawbar dynamometer showing location of strain gages

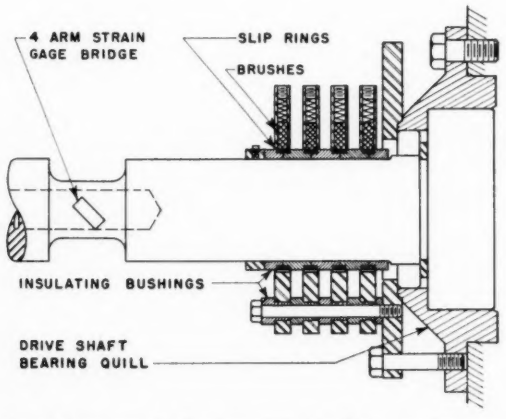

Fig. 5 Cross section of torque meter installed on transmission drive shaft

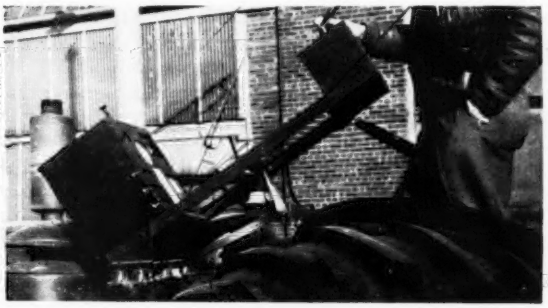

Fig. 6 Instrument box and recording camera installation on standard-tread tractor

shown in Fig. 2. A strain gage is bonded to either side of the spring, placing one in tension and one in compression when the spring is bent. The bridge is completed with two precision resistors which, with the other circuit elements, are contained in the cigar box. Consider the information that can be obtained from the spring. It can be calibrated with dead weights, plotting meter deflection versus weight for a particular value of bridge current which is standardized with the shunt calibrating resistance. The result is a portable remote reading scale. Many engineering laboratory experiments involve a determination of weight or force. Why not adapt this system to force or weight measurement in one experiment in place of the platform scale with which every student is already familiar? The spring might also be used as a position indicator by calibrating deflection versus meter reading. This particular spring in question is the governor loading spring from one of our engines. It is easy to calibrate it in terms of torque at the governor output shaft and obtain a record of governor force developed during a variable-speed engine test. This measurement was previously made with a string, a pulley, and a bucket of sand.

Convenience and novelty are hardly enough justification for a new method of measurement. Fig. 3 shows an installation of a strain-gage drawbar dynamometer which proved to be satisfactory in field tests to determine tractor-power requirements. The dynamometer is a steel ring fastened to the front end of the drawbar as shown in Fig. 4. Gages located at *A* and *B* are in tension and gages *C* and *D* are in compression when pull is applied to the drawbar. The dynamometer, therefore, satisfies the requirement of having tension and compression sections for most efficient use of gages. It is also self-compensating for temperature and for bending in the horizontal and vertical planes. This makes it possible to use the dynamometer as a part of the drawbar structure without additional supports, pivots, or knife edges. A ball-bearing-mounted roller was substituted for the rear drawbar support to eliminate friction at this point. The load on the drawbar was indicated by the circuit shown in Fig. 1 with a good quality commercially available 100 microampere panel meter.

A second transducer was employed on this tractor. A torquemeter consisting of strain gages mounted on a reduced section of the transmission drive shaft was installed. Slip rings made the electrical connection to the rotating strain-gage bridge. The design layout of this torquemeter is shown in Fig. 5. The indicating circuit was identical to that used for the drawbar dynamometer. The two meters, together with an engine tachometer, drive-wheel and front-wheel revolution counters, and a stop watch, were mounted on a single panel. Simultaneous recording of all the information was accomplished by photographing the panel with a 35-mm automatic camera. The instrument box, camera, and mounting rack installation on the tractor is shown in Fig. 6. The information recorded in this manner was sufficient to calculate engine horsepower developed and power required by implements at the drawbar.

Certain advantages accrue to this method of obtaining field data which are as applicable to field tests in a college course as to field tests to determine basic design data for industry:

1 Ease of calibration and stability combine to insure accuracy. The entire drawbar assembly with its indicating circuit was calibrated in a tensile testing machine. The calibration curves of drawbar pull versus meter deflection for the dynamometer before and after four weeks of continuous field use are shown in Fig. 7. There was less than 1 percent difference in the two calibrations.

2 The d-c circuit results in an electrically damped meter. This eliminates the high-frequency fluctuations making analysis of the data recorded by some other systems so difficult and time consuming. However, the meter responds rapidly enough to record the major variations in magnitude which determine the power requirement of an implement. Fig. 8 is a plot of drawbar pull versus distance traveled for a typical field run. This indicates the response of the system.

3 The 4½-in scale length of the meter makes it easily readable to 1 percent, giving a sufficiently high order of

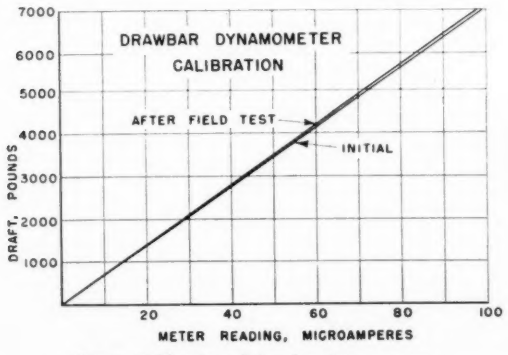

Fig. 7 Calibration of drawbar dynamometer

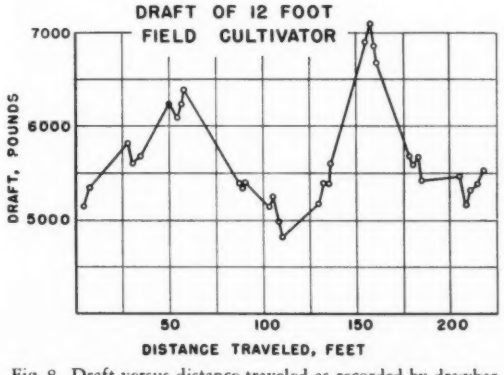

Fig. 8 Draft versus distance traveled as recorded by drawbar dynamometer

precision. This degree of resolution is achieved either by reading the negative of the film in a viewer, or by noting the meter reading visually and recording it on a clipboard when only one data channel is in use. Fig. 9 is a reproduction of one frame recorded by the camera. It was found that visual observation and recording could be made at the rate of one reading every 3 sec. Photographic recordings could be made at a rate as high as four per second if necessary.

4 The complete sensing and recording system is self-contained and mounted directly on the test tractor. Fig. 10 shows the same setup mounted on a row-crop tractor with a seat for the instrument operator. This allows tests to be made with considerable rapidity. Up to 30 runs, each of 35 data records, at different speeds, with various implements in several field conditions were made with a three-man crew in one day. This makes practical the accumulation of sufficient data to apply statistical methods to its analysis.

A college power and machinery laboratory should be able to equip a tractor with this type of instrumentation at a minimum of expense. Only the simplest of machine tools is necessary to make the few special parts required.

Aside from $30 worth of strain gages, the meters, and the camera, the material cost is negligible. Would not the construction, calibration, and verification of such a setup be a worthy project for a candidate for an advanced degree? Much valuable research work could then be done by succeeding graduate students using the equipment. Experiments to determine the quantity of data required to establish statistically sound conclusions as to effects of minor test variables would be especially helpful to industry. The first field test data from this unit operated on loose soil or on hills would emphasize the wide spread between engine power developed and drawbar power delivered. This would immediately suggest many graduate student or experiment station investigations to reduce losses between engine and drawbar due to rolling resistance, gravity, and slippage.

At the undergraduate level, a tractor equipped with this instrumentation would familiarize the student with strain-gage measurements in general. It would also implant in the student's mind the somewhat neglected thought that a disproportionate share of engine power and tractor fuel disappear between the clutch and the hitch point. The test tractor would also be a convenient means of measuring draft of various implements. Field experiments could then be conducted to verify theory as to speed-draft relations, power requirement versus amount of tillage accomplished, etc.

For more complete analysis of the dynamic behavior of the tractor, we have added supplementary equipment to that previously described. In determining total weight carried by the rear tires, it is necessary to know the weight transferred from the front wheels to the rear by the moment due to drawbar pull. This is usually calculated from drawbar height, wheelbase, and drawbar-pull measurements. However, when a tractor is in operation, these dimensions are different from the values measured under static conditions. The effective point of contact of the rear tire with the ground may or may not be in its static location at the surface of the soil and on a vertical line through the rear axle.* Therefore, the effective drawbar height and wheelbase may be changed from the quantities measured statically, causing an error in calculated weight transfer. Fig. 11 shows a strain-gage device for directly measuring weight on the front wheels of a row crop tractor. The front end weight, instead of being carried on the steering-spindle thrust bearing, is carried on a ring supported by the pedestal casting. Strain gages are applied to the ring and wired into a circuit in the same manner as for the drawbar dynamometer described previously. The ring is calibrated for axial load on the spindle. Any decrease from the static load carried by the ring must be the weight transferred to the rear wheels.

Two interesting possibilities are suggested by the use of this device in an agricultural engineering laboratory. First, it would simply be a graphic demonstration of the laws of statics applied to a tractor. Second, a careful analysis would reveal that the weight-transfer calculation does not hold exactly because of the change in point of contact between the tire and the ground previously mentioned. With weight

*Evaluation of factors affecting the operating stability of wheel tractors, W. H. Worthington. AGRICULTURAL ENGINEERING, vol. 30 (March, 1949), pp. 119-122.

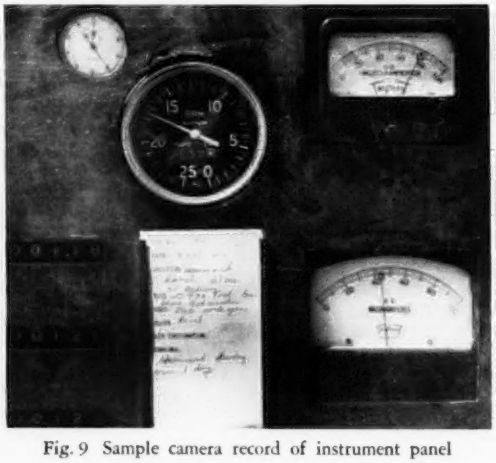

Fig. 9 Sample camera record of instrument panel

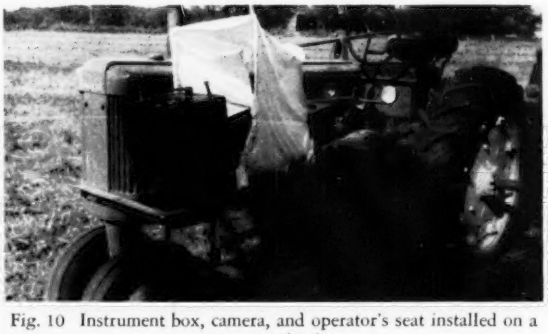

Fig. 10 Instrument box, camera, and operator's seat installed on a row-crop tractor

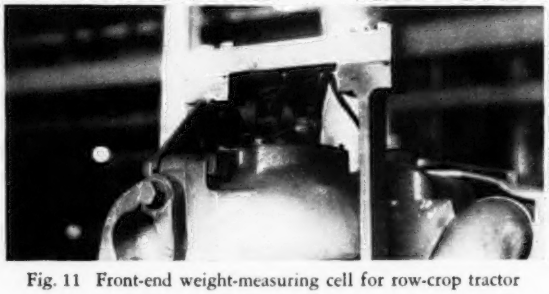

Fig. 11 Front-end weight-measuring cell for row-crop tractor

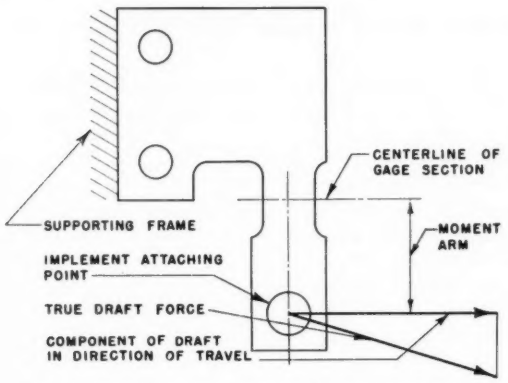

Fig. 12 Draft transducer for three-link implement hitches

transfer measured directly, the gross effect of this phenomenon on stability could be readily evaluated.

Another quantity which must be measured if we are to know the total rear-wheel weight is any vertical component of the drawbar pull. For most drawbar testing, the hitch is made level so no vertical component exists. This is satisfactory where a trailed traction dynamometer is used for the load but does not apply when pulling implements in the field. We have eliminated this limitation by installing a vertical drawbar-load measuring device on a tractor. This is simply a section of the drawbar immediately behind the rear drawbar support which has been reduced to increase the bending stress. With gages mounted symmetrically on either side of this section wired as opposite arms of the bridge, the bridge is sensitive to bending in a vertical plane only. Tension and bending in the horizontal plane cancel. It is assumed that the drawbar is horizontal.

Combination of a strain-gage drawbar dynamometer and the vertical drawbar-load sensing element would provide a useful instructional aid in teaching proper operating settings of implements, especially moldboard plows. Other things being equal, a plow and tractor combination ought to work most efficiently when the horizontal component of the plow draft is a minimum and the vertical component a maximum for added tractor drive-wheel weight. Having the equipment on the tractor for indicating these components directly would enable the student to see the effect of the various plow and hitch adjustments.

The preceding devices were applicable only to trailed implements. We have also used this type of instrumentation to measure horizontal draft of integral tools mounted with three-point linkage. The basic transducer element used for this is shown in Fig. 12. Three identical beams were used, one at each hitch point on the implement. The beam was supported at the point indicated by a subframe to which the tractor links were attached. The force developed by the implement at each beam caused a bending moment, measured by gages as shown. It will be seen that the bending moment at the strain-gage section is proportional to the component of force perpendicular to the axis of the beam, regardless of the direction of the force. By mounting the beam in the subframe so that the axis of the beam was perpendicular to the direction of travel, each beam indicated a draft force. A complete four-gage bridge was placed on each beam. The three bridges were wired in parallel so that the meter output was the algebraic sum of the output of all three beams, or the net implement draft.

These various transducers have been described to show that, in general, any force can be measured with a strain-gage element indicated by a simple meter circuit if the force can be made to bend a beam. To isolate the component of force desired, the beam is mounted to respond only to that component.

It must be emphasized that the d-c meter circuit is suitable for measuring static forces or averages of dynamic forces only. The meter does not respond nearly fast enough to measure peak forces or impacts. Neither does the meter circuit have sufficient sensitivity to measure strain in a single gage at the levels of stress ordinarily found in structural members of tractors or implements. The meter circuit depends upon use of more than one active gage mounted on a member with a low section modulus for high stress. Low values of static strain may be measured using the bridge circuit but substituting a moderately sensitive D'Arsonval galvanometer for the panel meter. Most industrial measurements of static strain are made with a portable indicator sold by the gage manufacturer. This instrument costs about $400. It is a practical, rugged device, is sensitive enough to measure strains of 10 microinches per inch, and is calibrated by the manufacturer.

Dynamic strains of average magnitude may be measured by an oscilloscope without preamplifier if the higher resistance gages are used. Recently developed stable d-c preamplifiers extend the usefulness of the oscilloscope greatly. Generally, some means of photographing the oscilloscope trace must be provided for dynamic strain measurement. Much of our laboratory work and some field tests have been

(Continued on page 634)

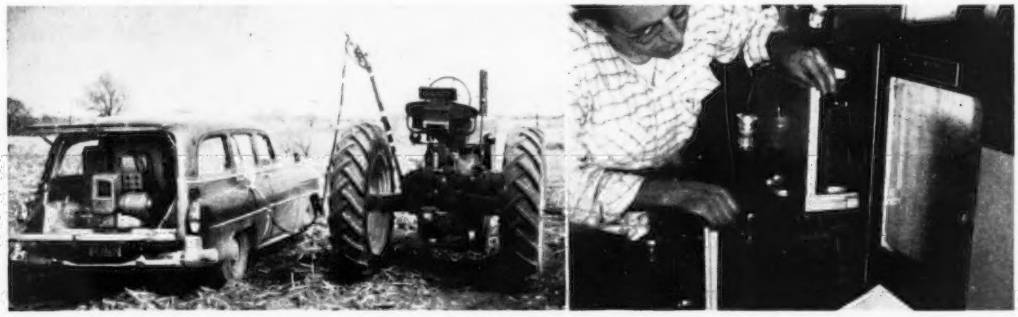

Fig. 13 *(Left)* Six-channel direct-inking oscillograph, amplifiers, and generator installed in station wagon for strain measurement in the field • Fig. 14 *(Right)* Interior view of station wagon showing oscillograph and amplifier mounting rack

Adapting Electric Motors to Farm Service

James B. Stere
Member ASAE

Development and Performance of Integral Horsepower, Single-Phase Electric Motors

BECAUSE the electric motor is the heart of many farm applications, it is timely to consider motors and to determine whether their development is in keeping with the needs and objectives of rural electrification. Fractional-horsepower motors have been so well built in to many farm applications that they have commonly been taken for granted. A water system, for example, almost inherently includes the electric motor. In the case of the submersible pump, it is the motor that has, in large part, been responsible for the development of the new type water system.

Designing farm equipment for and building in the larger horsepower motor, 3 to 10 hp has long been desired. Actually this era has arrived without being generally recognized. Growing pains of this new period has, however, been felt far, wide and deep. The slow and tedious job of developing electric-driven feed grinders, gutter cleaners, hay driers, silo unloaders, silo loaders, irrigation systems, automatic poultry and dairy feeders, etc., have presented new selling, serving and servicing problems, with new personnel and new companies becoming active. The facilities that have long been needed for expanding the applications of electricity on the farm are now available. With more unified effort and guidance, we can build the largest and most healthful period in the history of rural electrification.

Many have advocated three-phase electric service as a solution to the larger horsepower applications. If large power units are to be applied to inefficient systems and equipment without taking advantage of the automatic features available in motor-driven units to reduce labor, one form of power is then only substituting for another without either engineering or economic advancement. Many power suppliers are presently studying the advisability of extending and serving farm loads with three-phase service. With the new developments in the single-phase motor, with new equipment designed specifically for the efficient electric motor, with experiences of serving large heating loads on the farm, with the great potential improvements that can be made with the farm load-factor, and because of the heavy economic burden on users and suppliers alike, created by three-phase service, it does not seem likely that three-phase electricity will be widely served to typical size farms within the foreseeable future.

In view of this outlook, some motor manufacturers as long as 10 or 11 years ago started to redesign the larger single-phase motors to bring them more in line with the conditions and objectives of growing needs. Some of the early changes, unfortunately, were sideways or backward steps. We now believe, however, that these steps actually helped establish the foundation for present advancements. To appreciate what the recent changes mean to rural electrification, the new type motor will be compared in this paper with the repulsion-induction type which had long been considered a good farm motor.

Definitions

The repulsion-induction motor, according to the American Standards Association's definition, is a form of repulsion motor which has a squirrel-cage winding in the rotor in addition to the repulsion motor winding. The type of motor now generally replacing the repulsion-induction is known either as a capacitor-start, capacitor-run motor or a two-value capacitor motor (Fig. 1). There are so many kinds and varieties of capacitor motors that the simple term "capacitor motor" should never be used without additional qualification.

The two-value capacitor motor (Fig. 1) is defined as a form of capacitor motor that starts with one value of capacitance in series with the auxiliary winding and runs with a different value in series with the auxiliary winding. The change in value of capacitance may be performed with either two separate capacitors, controlled either with a centrifugal switch or an electrical relay or by one capacitor and an autotransformer with a transfer switch for changing the capacitor voltage and thereby changing the starting and running capacitance.

One of the outstanding features of the two-value capacitor motor is the simple squirrel-cage rotor. This type rotor eliminates commutator, brushes and rotor windings, all of which reduces maintenance and servicing costs, minimizes radio and television interference and lowers motor

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, on a program arranged by the Rural Electric Division.

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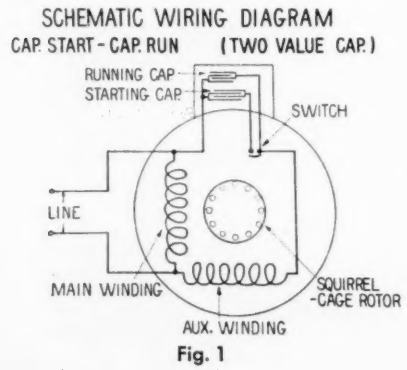

Fig. 1

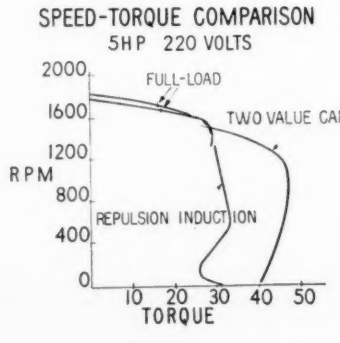

Fig. 2

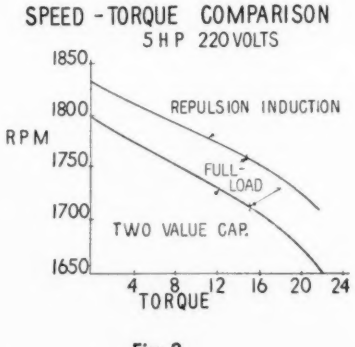

Fig. 3

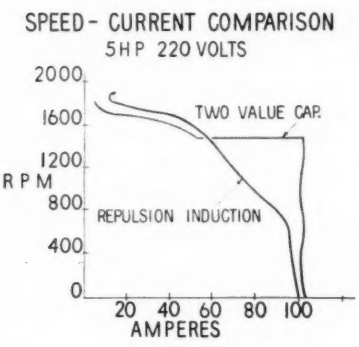

Fig. 4

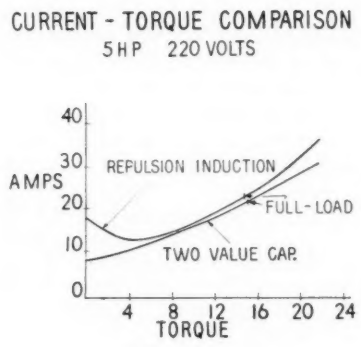

Fig. 5

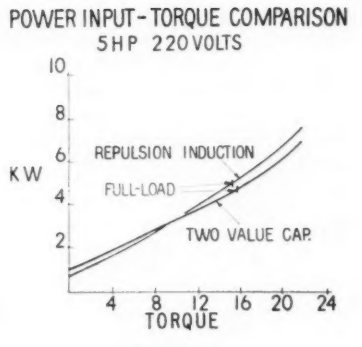

Fig. 6

noise level. The low noise level of this motor has made it difficult to manually regulate load by the sound of the motor and has given some the erroneous feeling that it is not as powerful as the repulsion-induction motor.

Speed-Torque

A comparison of the speed-torque characteristics (Fig. 2) show a wide difference in the starting and a slight difference in the running range. The speed characteristics of the repulsion-induction are such (note the rapid drop in speed for little change in torque before reaching maximum torque) that this motor is classified as either a constant-speed or a variable-speed motor.

When the repulsion-induction motor breaks its load loose, its torque falls off slightly; then it accelerates to full-load speed without materially exceeding its starting torque. This results in a slow acceleration of heavy starting loads. After the two-value capacitor motor starts its load, the torque increases through the largest portion of its speed range and consequently has rapid accelerating characteristics. So rapid is the accelerating of the two-value capacitor motor that close attention should be given to the design and adjustment of a belt drive in order to avoid either excess slippage or excess belt tension.

An enlarged section of the speed-torque curves (Fig. 3) (from zero to 145 percent full load torque) reveal little difference in the speed-torque characteristics in this range except that the speed of the two-value capacitor motor is lower on the speed scale and that the repulsion-induction motor will run above synchronous speed at light loads.

Speed-Current

In comparing motors either of the same type made by different manufacturers or of different types made by the same manufacturer, it is important that the comparison be made from tests that were run at the same voltage. All comparisons presented in this paper are from tests conducted with 220-v applied to the motor terminals at all times. Constant voltage, under starting conditions, is not, however, experienced in the field. For this reason the starting current does not reach the values shown in the speed-current curves (Fig. 4).

When large motors are started, even on the strongest rural line and farmstead wiring system, there is a reduction in voltage and an automatic reduction in starting current. Field studies conducted this year showed the starting voltage to range between 164 and 216 v. Because of reduced voltage, rapid acceleration and time lag in the fuse, both the 5 and 7½-hp two-value capacitor motors will start with a 60-amp link fuse in the line. The 10-hp size will start light loads with 60-amp link fuses and heavy loads with 60-amp time-delayed fuses.

Mainly because of the rapid acceleration, the effect of the voltage drop on the lighting system for starting a 10-hp two-value capacitor motor is less objectionable (from the present limited experience) than the effect of starting a 5-hp repulsion-induction motor.

Under light loads the current-torque characteristics (Fig. 5) of the two motors differ widely. The repulsion-induction motor draws 18 amp at no load and the same amount at near three-quarters load. This condition has caused considerable confusion among electricians and is an undesirable feature from the power supplier's standpoint. The near straight-line current characteristics of the two-value capacitor motor lends itself to automatic electric control and is more desirable from the power supplier's standpoint. There is hardly enough difference in full-load currents to materially affect farm wiring costs.

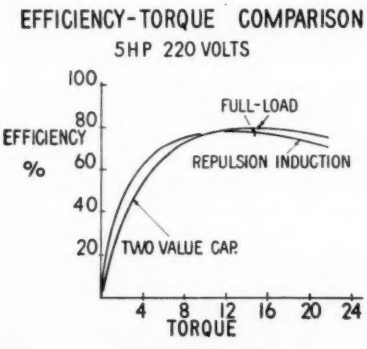

Fig. 7

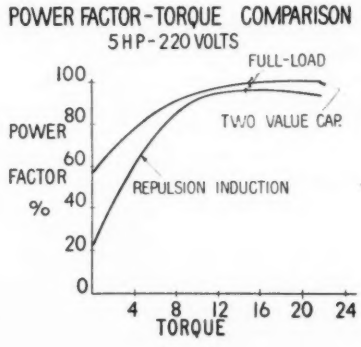

Fig. 8

Power Input-Torque

Power input (Fig. 6) to the two-value capacitor motor has a balancing effect to the familiar repulsion-induc-

tion motor. At full loads the two-value capacitor requires about 150 w less than the repulsion-induction motor. For long-hour operations this is a significant saving to the customer. At very light or no load the two-value capacitor motor consumes about 150 w more than the repulsion-induction. This is to the power supplier's advantage by providing means for charging for more of the energy actually used at light motor loads.

Efficiency-Torque

The effect of the power input, of course, shows up in the efficiency-torque comparison (Fig. 7), with lower efficiency at light loads for the two-value capacitor and higher efficiency at heavy loads. Increasing full-load efficiency of an already highly efficient simple machine, such as an electric motor, by 3 to 5 percent over a 10-year period, is a noteworthy achievement.

Power Factor

The improved power factor (Fig. 8) found in the two-value capacitor motor make this type of larger horsepower single-phase motors a more desirable load to serve. The near unity power factor and short duration of the starting current likens the two-value capacitor motor load to the heating and lighting loads.

Rural power suppliers who have studied the electrical characteristics of the two motors are accepting the 10-hp two-value capacitor motor as a desirable load for their reinforced rural lines. A field study made by one power supplier with the 10-hp size was reported by Mr. L. S. Singley at a meeting of the ASAE North Atlantic Section at Farmingdale, New York, in September, 1953: "Of the 11 farms included in the study, four were served from a 2300-v primary, two from 4600 and five from 6900." Of particular interest in the report, was the attitude of the distribution engineer which was summarized as follows: "Electric loads are growing at an unprecedented rate. Loads which looked big yesterday don't appear quite so large today. In the farm home alone —and in town too—we're serving 16-kw ranges, 4.5-kw clothes driers, and 1.5-kw water heaters. In addition, on the farm are 35-amp welders, other 1.5-kw water heaters in milkhouses, multiple installations of 5 and 7½-hp crop driers, 3.0-kw milkhouse space heaters, 3 and 5-hp barn cleaners, plus all other incidental loads. With these loads already being served, a 43-amp, 9-kw input motor becomes less of a problem."

Where the 10-hp motor will best serve a need is still somewhat speculative. Two apparent needs are for motorizing present equipment on the farm, such as feed grinders and silo fillers, and for increasing power needs such as irrigation, crop drying and the like. Many years of work in applying the 5 and 7½-hp motor to large engine-driven machines has not met with wide acceptance. The 10-hp motor may help span the gap between engine driven and electric-driven automatically fed and controlled unit machines.

The electrical and power developments of the two-value capacitor motor are of significant value and are in accord with the long-range rural electrification objectives. These developments should help increase the acceptance of the integral-horsepower single-phase motors by users, sales organizations, manufacturers and power suppliers.

Perhaps of more significance to users and sales organizations are the new design, maintenance and servicing features. In general, electric motors are becoming smaller. In the case of the two-value capacitor motor, the squirrel cage rotor has helped reduce size and weight. However, the advent of plastic insulating materials, light-weight metals and different fabricating methods have been responsible for a general reduction in weight and size. Reducing motor size and weight without simultaneously reducing price has, temporarily at least, produced a sales resistance rather than a sales aid. In the long run the reduced size should help the equipment manufacturer to build the electric motor into his equipment.

The reduced maintenance requirements of the two-value capacitor motor has promise of exceptionally worth-while benefits. Of the more than 1000 integral-horsepower motors of the type, that we have installed on farms in the past three years, the maintenance requirements and costs have been almost nothing. Ball bearings and the absence of brushes and commutator have eliminated frequent maintenance.

Service work on farm electric motors has almost always been considered a shop job. Service programs are usually based on this condition and the fact that competent field service is not generally available. The motor exchange plan, used by many manufacturers, distributors and dealers, where available and fully understood, has been a forward step in electric motor service. In the case of small repairs, however, the cost, due in part to travel and time and in delay, has not been in keeping with the apparent value of the service job.

The two-value capacitor motor opens new opportunities for rendering prompt and low-cost field service. Some manufacturers have already designed their integral-horsepower motors so the complete starting mechanism, running capacitors, bearings, rotor and end housings can be replaced in the field with few tools and by either available electricians or dealer servicemen. We hope that manufacturers can see their way clear to design this motor so the stator can be replaced in the field.

In our three years' experience with this type motor our service record reveals that equipment difficulties have not formed any pattern which would indicate a weakness in type. Either by correcting workmanship or material problems the difficulties have been cleared up. Contrary to reports, we have not had capacitor failures of serious magnitudes. We have had, however, the normal amount of criticism and skepticism that generally accompany new developments.

When service difficulties occurred and servicemen, who were unfamiliar with this type motor but otherwise competent, were called upon to make the repair, serious service problems sometimes did develop. The two-value capacitor motor does not respond to part failures in the same manner as other types. For instance, the capacitor-start motor will not have any starting ability if either the centrifugal switch, auxiliary winding or capacitor has so failed as to open the starting circuit. Even though the starting mechanism has failed in the capacitor-start motor, the motor may run in either direction if manually started and the running coils are undamaged. The two-value capacitor motor will start a light load with the starting capacitors out of the circuit and will run only in the direction for which it is wired. This new experience can provoke the wildest imagination of the best serviceman if he has not had advanced instruction.

"Of Cabbages and Kings"

Leonard J. Fletcher
Fellow ASAE

Some Thoughts on Humanistic-Social Studies in the College Training of "Complete" Engineers

A talk made to the engineering faculty and students in the College of Engineering at the University of Missouri on March 20, 1954, during the awarding of the 1954 Missouri Honor Awards for Distinguished Service in Engineering. Mr. Fletcher, one of the five recipients of the Award this year, is vice-president of Caterpillar Tractor Company, a past-president of ASAE, and the Cyrus Hall McCormick Medalist in 1944.

IN THE report of a survey entitled "How to Attract and Hold Engineering Talent," published by the National Society of Professional Engineers in February, 1954, issue of *The American Engineer,* it was stated that 88 percent of the executives of 200 firms employing engineers indicated their engineering graduates had an adequate background of scientific fundamentals; however, 62 percent of these executives felt that their young engineers were sorely deficient in other areas of study.

In the same survey, 28 percent of 1300 employed engineers felt that their college curriculum did not train them adequately for a career. Most of them indicated a need for more work in English, the social sciences and business administration.

My only comment, after seeing these percentage figures, is that it surprises me the executives did not consider more nearly 100 percent of these young engineers deficient in other areas of study, or that the engineers themselves did not unanimously admit a need for a considerable broadening of their education. In fact, surveys such as this invariably have shown that young engineering graduates are technically well qualified, yet deficient in many other areas of knowledge and experience. This information should come as no surprise to anyone having a first-hand acquaintance with undergraduate engineers, engineering faculty members and worried industrial executives trying to find ready-made "supermen."

There is every reason to believe that a young man successfully completing the prescribed work in an engineering curriculum wants to be an engineer. He puts first things first. He judges courses by the degree to which they allow utilization of a slide rule. He may recognize the importance of accurate and effective communications (this is spoken and written English in a new dress), yet he somehow realizes that he must first have engineering knowledge worth communicating. By observing the progress of the recent graduate in industry, he has learned that a sound grasp of the fundamental engineering sciences supplies the foundation on which his career is built. This undergraduate engineer also knows that regardless of the particular area in which he later applies his engineering knowledge, he will need to continue learning in both the technical and non-technical fields.

Just a few weeks ago, Mr. van Dyck of my company's education and training department interviewed a number of engineering seniors in the University of Missouri. He found that many of the young men with whom he discussed possible employment were concerned with how soon a young engineer entering our employ would be asked to take responsible charge of some engineering project. There was every indication that they were fully aware of their need for further education and experience. They were much relieved to learn that an adequate training and orientation program was provided by our company.

The young engineer engaged in research soon learns that it is not enough to discover the "new"—he must be able to convey effectively to others what he has learned, its importance, its possible use, and why and how the work should be carried on. Words are tools which the engineer must learn to use with increasing effectiveness as his work takes him farther away from the slide rule, the T square and the dynamometer. This ability has been reduced to the statement that every engineer must know how to "sell" his ideas. We cannot escape this competitive world and would not if we could.

Where to Gain This Knowledge

There is, of course, general agreement as to the value and need of added knowledge and ability in what might be called the broad, humanistic-social areas. The problem, as seen by many, narrows down to the question of where and how and when an indvidiual may best gain this knowledge. Should the responsibility for solving the problem be assigned to the high school, the college, the employer or, perhaps the engineer himself? From most accounts, it would appear that the customary answer of each of them to this problem is "It belongs somewhere else."

You may ask if any of these humanistic-social studies should be included in the curriculum of the engineering student. By all means, yes, but the teacher of these non-engineering subjects—whether English, economics, history, psychology or accounting—must meet satisfactorily the automatic question of this very professional-minded young engineer, "How will this help me to become a better engineer?" It is evident that this question is being satisfactorily answered in many cases. The faculties of our engineering schools are continuing to give our young engineers an excellent start, not only technically but in establishing well ideas concerning work and accomplishment. Even though there is now a high demand for engineering graduates, we in industry can see no slackening in the energy displayed on the job by our present young engineer or in his desire to prove himself—to make good. He knows that jobs are still held one at a time, and it is from this one job done well that he will advance.

Inspired teachers are creating interest on the part of undergraduates in these unexplored areas of humanistic-social studies, giving them that impetus toward learning that continues through life. No one ever receives an education. Everyone is self-educated. Learning requires the expenditure of energy and the student himself must supply this energy. Interest, however, serves as the fuel to drive the engine of study and makes the pursuit of knowledge in these new fields a challenge, a pleasure and a hobby. Learning is a continuous process throughout life. In college the rate of learning is high. Fundamentals are mastered. The individual

eventually reaches a place which justifies a change from paying to learn to "being paid to learn more"—which is not far from a correct description of the young engineer's early years in industry.

Personal Experience Is Best Teacher

Engineering knowledge, dealing as it does with materials and forces and design, can be recorded accurately, accumulated and transmitted. Each generation adds its part, and the world progresses engineering-wise. In these other fields of learning, so often described as being those neglected by the engineer—that is, the humanities and social sciences—there is no teacher like time and experience. Ability in this field "rubs off," so to speak, from those who possess it onto those with whom they work. Human relations are caught, not taught. Note that I said "ability" in these human relations, which I distinguish from "knowledge." A man may know all the answers, yet not be able to put them into practice.

The engineering faculty also has a responsibility for setting standards and building ideals of good communications and classroom management that will carry on in later life to better shop and drafting room and office relationships. After all, is it not generally true that we learn about "things" from books and the laboratory, and we learn about people from people? The habit of analytical observation, which becomes a part of every engineer, eventually brings understanding of the fundamentals of human behaviorism, whether observed in the market place, the political arena, the growing family, or from fellow employees.

Here I should explain the reason for the selection of the title of this talk. You may have assumed that I decided—as the walrus said—that

> "The time has come . . .
> To talk of many things,
> Of shoes—and ships—and sealing wax
> *Of cabbages and kings . . .*"

I have, however, quite another idea in mind. I wish to direct your attention to Charles Dodgson, the 19th century Oxford University mathematician and life-long teacher and author of books in his field of science. He would not even admit his authorship, under the pen name of Lewis Carroll, of the familiar and often quoted books, "Alice in Wonderland" and "Through the Looking Glass." Yet he stands as an example, so often repeated today, of a man whose creative, scientific mind carried him successfully into other fields of learning and accomplishment.

Where the Responsibility Lies

It was my privilege recently to attend a meeting of industrial representatives and engineering college deans to consider the much discussed report of the ASEE Committee on Evaluation of Engineering Education. It was clear that from the industrial viewpoint a good over-all job has been done in the education of engineers in this country. Technical accomplishments stand as proof. It was also made clear that we in industry do not hire curriculums or colleges (even though they might be starred). Rather, we employ men. We are, therefore, concerned with everything that goes into building the "complete" engineer.

As I read the Committee's report, I was particularly impressed with the first section dealing with the selection and development of an engineering faculty. I believe this to be the most important part of this report. Regardless of how well any job is currently being done, there is always room for improvement. Usually, this improvement can come better—and certainly with less pain—through self-analysis, self-criticism, self-improvement. It is likely that a serious study by any engineering faculty on how to produce this complete engineer will disclose that the principal responsibility lies with the engineering faculties. It is not enough that they concern themselves only with the technical subjects and then deftly funnel the young engineer into courses offered by the liberal arts colleges where it is hoped his "polishing" may be accomplished.

Engineering students, for example, will learn correct English more readily by being constantly reminded in their engineering classes and report writing than they will if the responsibility is delegated to an English department. I can still remember as an undergraduate my English teacher propping up in front of the class a copy of the painting Mona Lisa and then instructing us embryo engineers to write a 500 word essay on her smile. You see what I mean?

Furthermore, the resourceful technical man in industry, as he advances into greater responsibilities, finds available to him in his company and community many ways wherein he may improve his knowledge and ability in every field of learning. How well he utilizes these opportunities depends, to no small degree, upon the "seeds" of interest planted in his mind during his college days.

Experimental Stress Analysis

(Continued from page 629)

done with the oscilloscope, preamplifier, and continuous-motion camera. Figs. 13 and 14 show a six-channel direct-inking oscillograph with amplifiers installed in a station wagon . A gasoline-engine-powered generator is included in the equipment to make a self-contained, convenient means of obtaining dynamic strains in the field. Equipment of this type is sensitive and versatile enough to make almost any type of strain measurement encountered in farm equipment engineering.

Measurement of static and dynamic stresses as such in tractor and implement structures should add interest to design courses. Stresses could be determined at strategic points in the structure under loads as measured in the field. Such experiments would help fix in the student's mind the stress values used by engineers on successful designs, and would demonstrate the theory learned in earlier courses. Following this work with some dynamic measurements under actual operating conditions would show the student the reasons for using safety factors.

Strain gages are a powerful aid in the solution of engineering problems. Equipment required for their use need not be expensive. Use of strain gages in engineering college laboratories in ways similar to their industrial use would familiarize students with these methods. Furthermore, such usage would present experimental evidence of the theory of statics and dynamics.

Air Leakage in Controlled-Atmosphere Storage

I. J. Pflug and F. W. Southwick
Member ASAE

IN the CA (controlled-atmosphere) McIntosh apple storage it is desirable to obtain an atmosphere of 3 percent oxygen and 5 percent carbon dioxide as rapidly as possible after storing the fruit. In such rooms a level of 3 percent oxygen is obtained by allowing the respiring fruit to utilize and thereby reduce the oxygen level in the room. Any delay in acquiring the 3 percent oxygen level will tend to shorten the potential storage life of the fruit. Since no sealed CA storage room is 100 percent gastight, any movement of air through small leaks may be expected to influence the rate at which the oxygen level is reduced. The movement of air through small leaks in such storage rooms, the effect of this leakage in terms of added oxygen, and a method of reducing the influx of oxygen are discussed below.

During the 1952 apple storage season, observations made on a 3300-bu-capacity CA room indicated that a pressure fluctuation occurred. It was thought that the temperature cycling of the room could cause the specific volume of the atmosphere in the room to change and thereby create negative and positive pressures during the cooling off and warming portions of the temperature cycle. Since the structure is rigid but not hermetic, the room would "breathe" with each temperature cycle. It was concluded that, if the atmosphere did expand and contract, an appropriate contraction and expansion chamber might be used to reduce the amount of breathing and thereby increase the rate at which the oxygen level dropped after closing the room. A project was set up to study the problem during the 1953 storage season.

Paper prepared expressly for AGRICULTURAL ENGINEERING. Approved as Contribution No. 954 of the Massachusetts Agricultural Experiment Station, Amherst.

The authors — I. J. PFLUG and F. W. SOUTHWICK — are, respectively, associate professor of agricultural engineering and professor of pomology, Massachusetts Agricultural Experiment Station.

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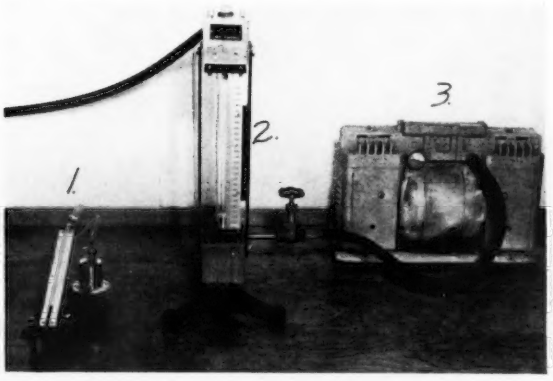


Fig. 1 Apparatus for measuring rate of leakage: (1) micromanometer, (2) flow meter, and (3) air compressor

Experimental

The study reported in this paper was made at the farm storage of a Massachusetts apple grower who had two similar CA storage rooms. These rooms were built in 1952 according to the general specifications given by Smock (3)*. The rooms were lined with aluminum sheeting and equipped with a sheet metal door in addition to a standard refrigerator door. The aluminum sheets were overlapped, and all joints caulked. The refrigeration system used F-12 as the refrigerant. One refrigeration system served both rooms; the temperature in each room was controlled by a remote bulb thermostat that operated the liquid line solenoid valve to that room. Each room was equipped with a scrubber constructed according to plans outlined by Smock and Van Doren (5).

The first phase of the project was measuring the rate of leakage of the rooms. A method was devised using a small air compressor for supplying air under pressure, a rotometer for measuring air flow, a valve for regulating air flow, and a micromanometer for measuring the difference between room and atmospheric pressure. This apparatus is illustrated in Fig. 1. The rotometer was calibrated for air flows of 25 to 200 cfh. The first step in the testing procedure was to seal the room and allow it to equilibrate in temperature with the surroundings. Air was then metered into the room at the rate of 25 cfh until the differential pressure reached a constant value. At this point the air was leaking out of the room at the same rate it was being added; therefore, the manometer reading was the differential pressure causing 25 cfh of leakage. The rate of flow was then increased to the next higher value, and the entire procedure repeated. The result is a graph relating pressure differential with rate of

*Numbers in parentheses refer to the appended bibliography.

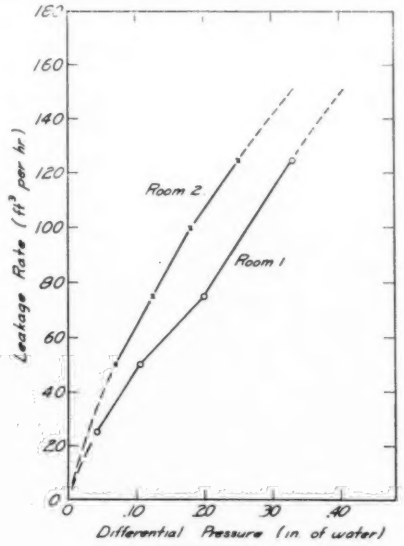


Fig. 2 Leakage rate graph

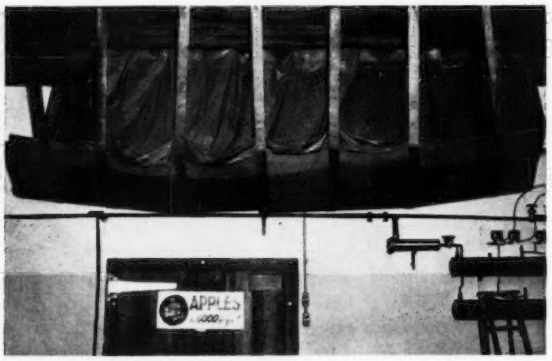


Fig. 3 Expansion bag connected to room

leakage; in Fig. 2 the leakage rate graph for the two rooms under study is illustrated. The maximum pressure put on the room was relatively low because it was felt that high pressure would serve no useful purpose in this test and might cause more leaks in the room.

Since pressure differentials were to be studied, two recording differential manometers were obtained, and one was connected to each room. A temperature-sensing element was located in each room and connected to a multiple-point recorder so that a continuous record of temperature in the room would be available. The empty rooms were refrigerated at this time and several tests made to determine the pressure fluctuations. Empty room tests showed definite pressure fluctuations accompanying temperature changes.

A bag 12 by 16 ft (flat size) made of vinylite plastic sheeting was attached to room No. 2 as shown in Fig. 3 as a means of reducing pressure differentials. Initially the bag was connected to the room with 1⅜ I.D. hose and 1¼ Am. Std. pipe. In March, 1954, some 2⅝ I.D. flexible metal hose was obtained; this was used to connect the bag to the room for a 3-day test period.

The bag was hung from the ceiling as illustrated in Fig. 3. The bottom of the bag was supported by straps about 6 ft below the ceiling in an effort to reduce the pressure required to move and hold air in the bag. It was found that supporting the bottom of the bag was not enough; so a few weeks after installation one side of the bag was tied back to maintain more air in the bag at equilibrium pressure. Room No. 1 was not equipped with a bag and therefore would serve as a control in the evaluation of the breather bag.

The rooms were filled to capacity with apples during the latter part of September. The recording thermometers and manometers were operated the entire length of the storage season giving a complete pressure and temperature record for both rooms. In addition the operator of the storage measured the oxygen and carbon dioxide levels twice daily.

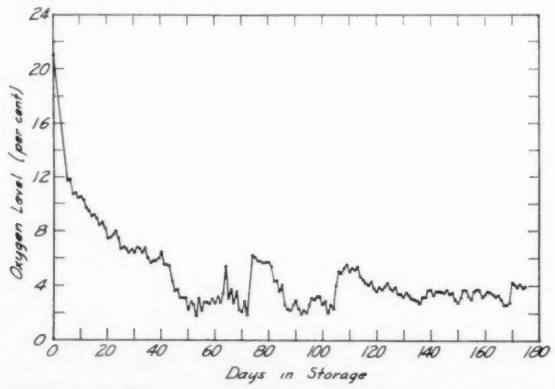
Results and Discussion

The breather bag appears to have had a marked effect in reducing the oxygen level in the rooms under study, as illustrated in Figs. 4 and 5. The oxygen levels plotted on the graph in Figs. 4 and 5 are an average of the two daily readings. The oxygen level in the No. 2 room (initially connected to the breather bag) was reduced to 2.7 percent in 23 days. The No. 1 room (initially without the bag) had an oxygen level between 7 and 8 percent, 22 days after sealing; about 6 percent, 40 days after sealing. A breather bag was connected to the No. 2 room on October 31, 42 days after the room was sealed. Eight days after the bag was connected to the No. 1 room the oxygen level was reduced to 2.2 percent. A serious F-12 leak developed in room No. 2 and required that the door be removed and the leak repaired. Although the door was off for only an hour, the oxygen level the following day (January 5, 1954) was 15.4 percent. The oxygen level was reduced to 3.1 percent in 22 days as illustrated in Fig. 5; during this period the room was connected to the bag.

The pressure variations of room No. 2 are illustrated on the recorder charts shown in Figs. 6, 7, and 8. It is obvious when the pressure differentials of Figs. 7 and 8 are compared that the 1⅜-in I.D. hose and pipe are too small.

When the rooms were connected to the breather bag, it was difficult to keep the oxygen level up to between 2 and 3 percent. It was found that, if the bag was disconnected or shut off, the rooms would maintain an almost constant oxygen level without adding any ventilating air. On several occasions the CA oxygen content went above the desired level; at these times the bag was connected to the room and the oxygen level was brought down in a few days.

One of our breather bags was used by Smock and Branton (4) for a few weeks during December, 1953, and January, 1954. Their results indicated that the bag helped to reduce the oxygen level of the room. The bag plus nitrogen gas had more effect than the bag alone.



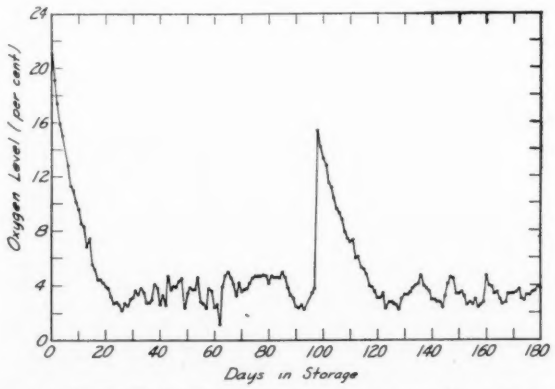


Fig. 4 *(Left)* Oxygen level in storage room No. 1 during storage season • Fig. 5 *(Right)* Oxygen level in storage room No. 2 during storage season

An analysis was made of the variables affecting the oxygen level of the CA storage in an attempt to rationalize the results obtained. The quantity of air drawn into the storage during each temperature cycle was obtained by using the differential pressure data illustrated in Figs. 6, 7, and 8 to find the rate of leakage from Fig. 2. A curve of leakage rate as a function of time was then plotted, and the area under the curve, leakage per cycle in cubic feet, was obtained by measuring the area under the curve with a planimeter and multiplying by the unit area factor. The average of a number of these analyses gave the leakage through cracks per temperature cycle as 4.27 cu ft without the breather bag, 1.72 cu ft when the bag was connected with the 1⅜-in hose and 0.65 cu ft when the 2⅝-in hose was used.

The average temperature cycle of the storage room under study was about 0.5 F. The volume change calculated by the general gas law $PV/T=P'V'/T'$ for a room containing 4330 cu ft of atmosphere, for a 0.5 F temperature change assuming the pressure is constant is 4.4 cu ft. Using the same equation and temperature condition, the pressure change for a rigid hermetic room would be 0.4 in of water. The behavior of the room therefore can be explained by physical laws.

The flexible breather bag, theoretically as part of the room, permits the volume of the room to change as the volume of the atmosphere in the room changes with temperature and pressure. From a practical standpoint, we can only approach this ideal situation because of the weight of the bag and the pressure drop in the elements connecting the expansion chamber with the room.

The oxygen used by the fruit under CA conditions of 3.5 percent O_2 and 5 percent CO_2 calculated from data presented by Van Doren (6) is 46.5 cu ft per day. The air leakage of room No. 2 (the product of the number of temperature cycles, average of 70 per day, and the leakage rate per cycle, 4.26 cu ft) is 303.2 cu ft per day when the room is not connected to the breather bag. Using a modification of the formula presented by Sainsbury and Gerhardt (2), the calculated oxygen gain under the condition illustrated in Fig. 7 is 52.3 cu ft per day. With the bag connected under conditions illustrated in Fig. 8 the oxygen gain is only 21.0 cu ft per day.

An analysis of the refrigeration loads of the rooms under study showed that over 80 percent of the cooling load, after removal of field heat, was due to the motors and fans of the unit coolers and a carbon air purifier. The unit cooler and air purifier fans were operated continuously.

Kidd and West (1) point out that barometric pressure changes can affect the time required to obtain the desired atmosphere. A study was made of cycles of the barometric pressure at Amherst, Mass., between October 1, 1953, and March 1, 1954. It was found that the average major cycle required six days and had a range of 0.63 in of mercury (8.58 in of water). The effect of these barometric pressure changes on the storage rooms in this study is to increase the oxygen level by about 15.7 cu ft per barometer cycle, or 2.6 cu ft per day. It appears that the oxygen gain from barometric pressure changes is small compared to the oxygen gain of a room without a breather bag.

In general, this study indicates that a breather bag will probably increase the rate of oxygen reduction of a CA storage that has off-on temperature control and is 92 to 95 percent tight according to Smock (3). The greatest benefit will probably be in small rooms with unit coolers.

It is doubtful if the breather bag aids in reducing the oxygen gain from barometric pressure cycles. Oxygen gain due to scrubbing out carbon dioxide also seems to be beyond control with the breather bag, since the volume of CO_2 scrubbed out must be replaced by air from outside the storage if equilibrium is to be maintained. The bag will improve the operation of a tight room but will do little for a leaky room.

Summary

Observations made during a one-year study of pressure, temperature, and volume relationships of a CA apple storage have been outlined. A method of testing a CA storage for rate of leakage has been described and test data presented. Results from the use of a breather bag to increase the rate of oxygen reduction have been discussed.

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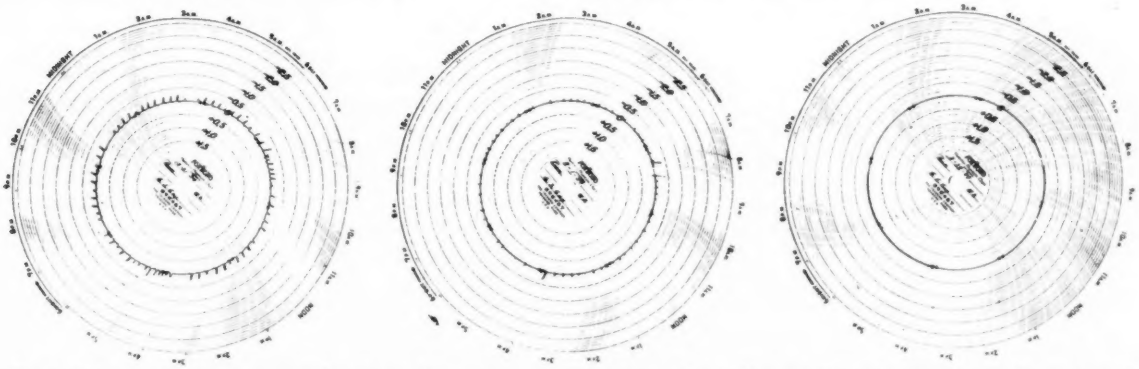

Fig. 6 *(Left)* Chart showing pressure fluctuations of storage room without bag • Fig. 7 *(Center)* Chart showing pressure fluctuations of storage room connected to breather bag with 1⅜-in elements • Fig. 8 *(Right)* Chart showing pressure fluctuations of storage room connected to breather bag with 2⅝-in elements (Pressures in Figs. 6, 7 and 8 are in inches of water)

Hot Weather Shelters for Livestock

The Use of Sol-Air Temperature Measurements in Summertime Animal-Shelter Research Studies

G. L. Nelson, Member ASAE, G. W. A. Mahoney, Assoc. Member ASAE, E. R. Berousek and Franklin Graybill

IN experiments with the performance of hot-weather shelters for livestock, the effects of solar radiation and ambient air temperatures on heat gain to and through building surfaces and materials are important. The effects of ambient air temperature and solar radiation on surface temperatures of livestock likewise help to evaluate the effect of hot-weather shades and shelter on livestock. These two factors, solar radiation and ambient air temperature, are not independent insofar as their effects on temperatures of building or animal surfaces are concerned. This is true because surface characteristics determine both the absorptivity coefficient for solar radiation and the coefficient of convective heat transfer. Under the usual summertime conditions, a surface exposed to solar radiation will experience a temperature rise above ambient air temperatures. The temperature rise will be limited by heat transferred away from the material by free or forced convection and reradiation, and into the material by conduction.

The Sol-Air Temperature Concept

A convenient index for evaluating the combined effects of solar radiation, ambient temperatures, wind velocity, and surface characteristics is the "sol-air" temperature. The 1953 ASHVE Guide(1)* defines sol-air temperature, t_e, as

$$t_e = t_o + \frac{OC_D\, I_D + OC_d\, I_d + \varepsilon_L\,(R_S - R_L)}{f_{co}}$$

where OC = absorptivity of weather side of the surface for solar irradiation, dimensionless (Subscripts D and d refer to direct and diffuse, or sky radiation, respectively)

I = solar irradiation, Btu per(sq ft)(hr) (Subscripts D and d refer to direct and diffuse irradiation, respectively)

ε_L = emissivity of surface at temperature t_L, dimensionless; and absorptivity for R_S, dimensionless

R_S = long wave length (low temperature) radiation from outdoor surroundings, Btu per(hr)(sq ft)

R_L = low-temperature radiant energy emitted by a black body at temperature t_L, Btu per(hr)(sq ft)

f_{co} = coefficient of convective heat transfer for the surface, Btu per hr sq ft(deg F temperature difference).

Sol-air temperature may be regarded as the temperature to which the ambient air should be heated to produce the same rate of heat gain to the surface if it were shielded from radiant-heat exchange with the sun, sky, and surroundings as actually occurs under the existing ambient temperature, radiant-heat exchange with the sun, sky, and surroundings, and wind velocity. Therefore, it is seen that the sol-air temperature is an index temperature that takes into account the surface characteristics that influence radiant and convective heat exchange, the ambient air temperature, irradiation to the surface, and wind velocity. The sol-air temperature is useful for quantitatively evaluating the effect of different environmental conditions on heat gain to a given surface, or for comparing the effects of a given environment on heat gain to different surfaces.

If the sol-air temperature of a surface is known, the net heat gain to the surface can be computed by

$$(q/A)_L = f_{co}(t_e - t_L)$$

where $(q/A)_L$ = heat gain to the surface, Btu per(hr)(sq ft)

t_L = surface temperature, F

Air-conditioning engineers use the sol-air temperature concept in computation of heat gain to building surfaces. It has been the subject of considerable study, and rapid methods for computing periodic heat gain through building components under summertime conditions have been developed based upon the application of sol-air temperature data.

In research at the Oklahoma Agricultural Experiment Station on summertime shelters for dairy cattle, the sol-air temperature concept was used as a basis for evaluating the heat-gain characteristics of different types of concrete masonry-wall construction in a cooled dairy-cattle shelter, for comparing surface temperatures of three types of metal roofing, and for evaluating the surface temperature response of dairy cattle to different outdoor summertime environmental conditions.

Sol-Air Thermometer Theory

If values for the surface constants of solar-irradiation absorptivity, emissivity for long wave length radiation, and convective heat transfer are known, the sol-air temperature can be computed for any set of environmental conditions. However, these constants have not all been evaluated for farm building construction materials or surfaces of farm animals. In the absence of quantitative data on surface characteristics, sol-air temperatures can be measured directly with a sol-air thermometer, first described by Mackey and Wright(3). The theory of the sol-air thermometer is developed as follows:

Let a surface for which sol-air temperatures are desired be exposed to some definite solar irradiation, ambient dry-bulb temperature, and wind velocity. Assume the surface to be perfectly insulated against heat transfer away from the surface not exposed to radiation. A certain surface temperature rise will occur such that the heat transfer to the surface by radiation must be equal to the transfer away from the surface by convection and long wave length radiation. This can be expressed in equation form as follows:

$$OC_D\, I_D + OC_d\, I_d + \varepsilon_l R_s = f_{co}(t_s - t_o) + \varepsilon_l R_l$$

Solving for t_s

$$t_s = \frac{OC_D\, I_D + OC_d\, I_d + \varepsilon_l(R_s - R_L) + t_o}{f_{co}}$$

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Minneapolis, Minn., June, 1954, on a program arranged by the Farm Structures Division.

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*Numbers in parentheses refer to the appended bibliography.

However, the right-hand side of this expression is, by definition, the sol-air temperature. Therefore, the sol-air temperature can be measured by mounting a specimen of the surface for which sol-air data are desired on a perfectly insulated backing, exposing the surface to outdoor conditions, and measuring the surface temperature. The term

$$\frac{OC_D I_D + OC_d I_d + \varepsilon_L (R_s - R_L)}{f_{co}}$$

may be rewritten in abbreviated form for upward facing surfaces as

$$b/f_{cro} I$$

where b=absorptivity of the surface for solar irradiation, dimensionless

f_{cro}=combined surface coefficient for convective and radiant heat transfer, Btu per(hr)(sq ft) deg F temperature difference

I=solar irradiation on the surface, Btu per (hr)(sq ft)

Although this abbreviated form does not identify each of the several characteristics of the surface that influence radiant and convective heat exchange, it does make a useful distinction between these two modes, and has the advantage of brevity for use in analyzing experimental data. The earlier literature(2) on sol-air temperatures uses this abbreviated form for defining sol-air temperatures as follows:

$$t_e = \frac{b}{f_{cro}} I + t_o \ .$$

If this definition is employed for sol-air temperatures, it is apparent that the surface characteristics which influence the combined effects of solar irradiation and ambient temperature can be evaluated by the ratio b/f_{cro}, which ratio is therefore a convenient index for comparing surfaces with regard to their effectiveness in reducing heat gain under environmental conditions. In this ratio, b should be less variable than f_{cro} which will be influenced primarily by wind velocity, and to some extent, temperature, and surface attitude with respect to vertical. Therefore, by measuring sol-air temperatures with a sol-air thermometer, and simultaneously measuring I, t_o, and wind velocity, b/f_{cro} can be computed for various wind velocities. Then b/f_{cro} can be used to compute sol-air temperatures under any given set of environmental conditions for a surface with the same attitude as the one on which the measurements were made.

Sol-Air Thermometer Construction

Two different modifications of the type of sol-air thermometer described by Mackey and Wright were used for obtaining sol-air temperature data in this study.

The thermometer used in measuring the sol-air temperatures of masonry surfaces and metal roof covering surfaces was a 12-in aluminum-foil-covered cork cube. Recesses 8 in square and 1 in deep were cut into the top and each side of the cube to receive panels, each constructed as 4 sandwiches of 4 aluminum-foil-bounded air spaces, ¼ in thick.

Concrete masonry samples for sol-air temperature studies were made of portland cement and aggregate. Aggregates used were the same as those in the masonry units in 12 test panels in the west wall of a cooled dairy cattle shelter, namely, expanded shale, pumice, and sand and gravel. A mixture of one part portland cement to 4 parts aggregate by volume was used for making the samples. The rich mixture was needed to prevent breakage in handling and to sufficiently coat the small particles of aggregate. The samples were 2½ in in diameter and ¼ in thick.

One 30-gage iron-constantan thermocouple junction was imbedded in each sample of concrete masonry as it was cast. Half the samples of each aggregate were painted white to simulate white painted walls, and half were unpainted.

Metal-roofing material samples for sol-air temperature studies were cut from weathered aluminum sheets, weathered galvanized steel sheets, and unweathered steel sheets with a glossy gray, baked-on enamel coating. Three samples 2¼ in in diameter and one sample 3¾ in square were cut from both the aluminum sheet and the galvanized steel sheet. The single specimen of enameled steel was 5 in by 8 in. One 30-gage iron-constantan thermocouple junction was soldered to the back of each of the smaller samples and three were soldered to each of the larger samples.

The masonry and metal roofing samples were mounted on the sol-air thermometer with rubber cement. The masonry samples were mounted in six groups of three samples each. These six included one group each of the three types of aggregate unpainted, and one each painted white. The metal-roofing samples were similarly mounted.

The thermometer used in measurements of sol-air temperatures of cattle surfaces consisted of a cork slab 12 in by 36 in by 4 in thick. One face of the cork slab was prepared to receive four cow skin specimens by cutting four recesses each 3 in by 3 in by ¾ in deep into the surface of the slab. Then 3 layers of aluminum foil separated by ⅛-in square balsa strips were installed in each opening. The specimen was then mounted at the top of the opening with a foil lining on the back of the specimen. This resulted in an insulating backing for each specimen that consisted of three air spaces with reflective lining in each side, plus approximately three inches of cork. A typical section through one of the pockets is shown in Fig. 1.

The specimens of cattle surfaces were ob-

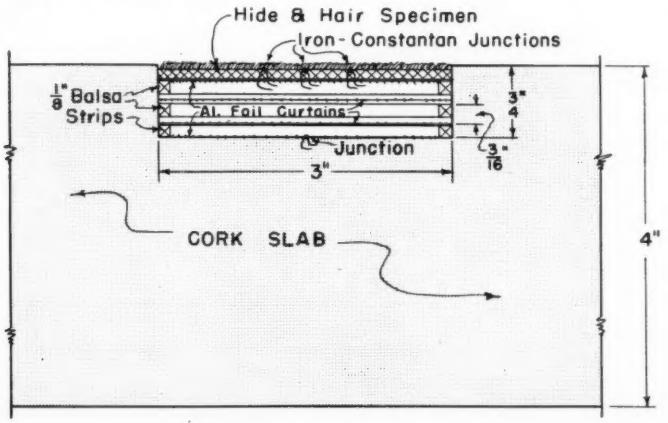


Fig. 1 Section through sol-air thermometer for sol-air temperatures of cattle surfaces

tained from cattle delivered to the diagnostic laboratory of the school of veterinary medicine. The specimens were removed from the back or upper neck and refrigerated until mounted for drying. Drying treatment consisted of stapling the specimens hair side down to a 1-in board, then covering them with salt. After curing for approximately two weeks, they were removed and trimmed to a size of 3 in by 3 in. This curing process appeared to retain all the original qualities of the hair and skin surface except that the hide became quite stiff and hard. The thermocouple junctions were installed by drilling two small holes through the hide at the location of each junction, inserting the wires from the back of the specimen, and then soldering the ends. Each junction was then pulled back so that it was flush with the surface, where it was held in place with small balsa splints plugged into the holes and cemented. Three junctions spaced 7/8 in apart were installed in each specimen. Thermocouple junctions were also installed at the base of each pocket, and on the surface of the cork slab for measurement of slab-surface temperatures.

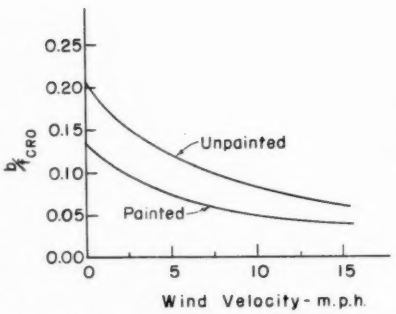
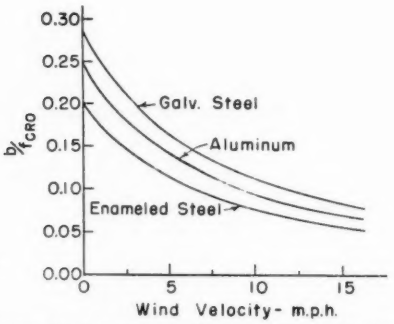


Fig. 2 *(Left)* Surface characteristic, b/f_{cro}, for concrete block masonry surfaces • Fig. 3 *(Right)* Surface characteristic, b/f_{cro}, for metal roof coverings



The sol-air thermometer was placed on a surveyor's plane table and levelled at a height of approximately four feet above ground. A series of specimen surface temperature readings was taken every ten minutes by means of an electronically balanced potentiometer. Wind travel during the two or three-minute intervals that elapsed while each set of temperature readings was being taken was measured with a rotating-vane anemometer mounted on a simple wind vane. Solar irradiation data were obtained by an Eppley pyrheliometer on the roof of the campus weather observatory about 40 ft above and 500 yd distant from the site of the sol-air thermometer. Air temperatures were measured by a junction hung in the shade under the sol-air thermometer.

It is obvious that a sol-air thermometer of practical size, such as the ones that have been described, will not provide the exact circumstances needed according to theoretical considerations for measurement of sol-air temperatures. The shape and size of the thermometer itself will have some effect on the f_{cro} factor. Furthermore, the specimen will not be perfectly insulated from heat transfer in directions other than the direction which the specimen faces. However, errors due to departure from ideal conditions are believed to be small. An analysis was made to ascertain the order of magnitude of the error due to imperfect insulation. This analysis proceeds as follows:

Let t_s = surface temperature of specimen, approximating the true sol-air temperature, t_e, F

t_e = true sol-air temperature of the specimen, F

C = over-all conductance between specimen surface and bottom of recess in cork slab, Btu per hr sq ft, F

b = absorptivity of specimen for solar irradiation, Btu per sq ft hr

f_{cro} = surface coefficient of specimen for combined convective and radiant heat transfer, Btu per sq ft hr, F

I = solar irradiation on surface, Btu per sq ft hr

t_b = temperature at bottom of recess in cork slab, F.

By writing a heat balance on the surface, assuming that all heat transfer is normal to the surface, and that the surface faces upward so that irradiation from the surround is negligible, we obtain:

$$bI = f_{cro}(t_s - t_o) + C(t_s - t_b) \quad . \quad . \quad . \quad . \quad . \quad [1]$$

From the definition of sol-air temperature, we obtain

$$t_o = t_e - \frac{b}{f_{cro}} I \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

Substituting for t_o from equation [2] in equation [1], rearranging, and dividing by $(C + f_{cro})$, we obtain

$$t_e - t_s = (t_s - t_b)\frac{C}{f_{cro}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

The temperature, t_b, at the bottom of each of the pockets in the sol-air thermometer used for the cow-surface speci-

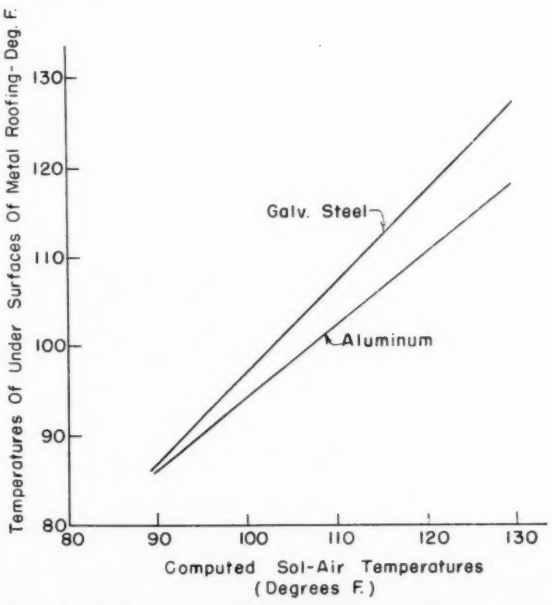


Fig. 4 Temperature of undersurface of roof coverings as a function of sol-air temperature

mens was measured when the surface temperatures were observed. These t_b measurements can be used in equation [3] to compute a correction for t_s to give a closer approximation to t_e. If values of 3.0 for f_{cro}, and 0.07 for C are taken, the discrepancy between t_s and t_e due to imperfect insulation is

$$t_e - t_s = (t_s - t_b)\frac{0.07}{3.0}$$
$$= 0.023(t_s - t_b)$$

The temperature differences, $t_s - t_b$, never exceeded 35 deg, and seldom exceed 25 deg. Computing $t_e - t_s$ for $t_s - t_b = 35$ deg, we obtain $t_e - t_s = 0.805$ deg. Therefore, it is believed that the errors due to imperfect insulation are in the order of 1 deg or less.

Analysis of Sol-Air Temperature Data for Building Material Surfaces

The values of b/f_{cro} for the samples of concrete masonry surfaces tested were computed using the formula

$$\frac{b}{f_{cro}} = \frac{t_e - t_o}{I}$$

where I is the solar irradiation on the surface, Btu per sq ft hr received on west facing vertical surfaces and t_e is the measurement with the sol-air thermometer. The solar irradiation was computed using the expression $I = K I_n + I_{sv}$, where K is the cosine of the angle of incidence of the suns rays on a vertical, west-facing surface; I_n is the intensity of direct irradiation on a plane normal to the sun's rays, and I_{sv} is the sky irradiation on any vertical surface. A supplemental analysis was made to compute I_n and I_{sv} from the single value I_h, the total solar and sky irradiation received on the horizontal surface of the continuous-recording pyrheliometer operated by the college meteorology department. Instantaneous values of t_e were taken as the average observed temperatures of the three similar samples of materials being tested. Wind velocities during sol-air observations were also recorded and the values of b/f_{cro} were plotted for wind velocities from 0 to 15 mph as shown in Fig. 2. It was found upon plotting the b/f_{cro} values that no significant differences existed among values for the three types of masonry surfaces namely, expanded-shale aggregate, pumice aggregate, and sand-and-gravel aggregate. Therefore, the curves of Fig. 2 represent the results for these three types of aggregate in the masonry surface. These values of b/f_{cro} can then be used to compute t_e for any surface similar to those tested if outdoor air temperature, wind velocity and direction, and solar irradiation are known.

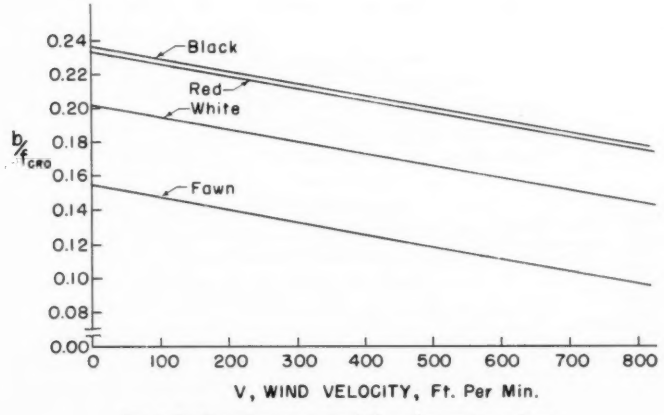


Fig. 5 Surface characteristic, b/f_{cro}, for cattle surfaces

The b/f_{cro} data for concrete masonry surfaces were then used as a basis for correlating sol-air temperatures with heat gain through 12 kinds of concrete block masonry panels in the west-facing wall of a cooled dairy cattle shelter. This shelter has been described in another paper(5). Heat gain to the interior of the building for selected days during the summer of 1950 was measured with a Gier and Dunkle heat-flow meter as described by Mahoney(4). Sol-air temperatures were computed for corresponding times. By plotting sol-air temperatures and heat gain on the same time scale, the time lag between maximum sol-air temperature difference and maximum heat gain to the building interior can be ascertained. Furthermore, the ratio

$$\frac{(q/A)_i \max}{(t_e - t_i) \max}$$

where $(q/A)_i \max$ = maximum heat gain rate to interior air, Btu per hr sq ft

$(t_e - t_i)\max$ = maximum difference between sol-air temperature, t_e, and constant indoor temperature, t_i (deg F)

can be used to compute a factor which has the same dimensions as an over-all air-to-air conductance coefficient, U, and is here termed U_e. This factor, U_e, can be used to compare different kinds of concrete-masonry wall construction and to evaluate maximum summertime heat gain. The results of this analysis are presented in Table 1. The values for "lightweight" block are averages of the measurements for concrete block made with pumice aggregate and expanded-shale aggregate, respectively. The values for "standard" block are the results of measurements on block made with sand-and-gravel aggregate. The benefits of white paint on the exterior surface are evident except in the case of the standard block with empty cores. This block had an unusually smooth, light-colored exterior surface in its unpainted condition. It is, therefore, probable that the actual sol-air temperatures of this block were lower than the combined values from measurements on sample surfaces, with the result that the U_e value computed for it is too large. Therefore, it is believed that a value between 0.50 and 0.55 would be a better approximation for U_e for white-painted concrete block with cores empty.

TABLE 1. Comparative Heat Gain Characteristics of 8-in Concrete Block Masonry

Exterior surface treatment	Core spaces	Time lag, hr		U_e Btu per hr deg F	
		Light-weight block	Standard block	Light-weight block	Standard block
Unpainted	Filled	5	4	0.34	0.53
	Empty	3¾	2½	0.41	0.59
Painted	Filled	3¼	2½	0.27	0.43
	Empty	3½	2	0.37	0.67

These results were borne out by numerous temperature measurements during the summer

of 1951 on the interior and exterior masonry-wall surfaces. For example, on a typical July day, the outdoor surfaces of the unpainted panels had an average maximum temperature of 23.3 F warmer than the painted panels. The interior surfaces of the unpainted panels averaged 4.4 F warmer than the painted panels.

Reduction of heat gain to the building due to painting the exterior surfaces white can be accomplished at little additional cost in concrete-masonry structures, especially since concrete-masonry walls usually need to be painted for increased resistance to moisture penetration.

Values b/f_{cro} for metal roofing surfaces were obtained in the same way as were data on masonry surfaces. These values are shown in Fig. 3. These values obtained were used to compute sol-air temperatures of galvanized steel and aluminum roofing in place on an open-front loafing barn. Sol-air temperatures were then correlated with observed temperatures of the under side of these metal-roofing sheets of aluminum and galvanized steel. This correlation of measured roofing temperatures and computed sol-air temperatures is shown in Fig. 4.

Sol-Air Temperature Measurements of Cattle Surfaces

Two replications of cow-surface specimens of each color —black, red, fawn, and white, were used in the sol-air temperature measurements with cow surfaces. The two black specimens were from the back of a mature Holstein cow and a 16-month-old black Angus bull, respectively. The hair on the specimen from the Angus bull was somewhat coarser and longer than the hair on the Holstein cow specimen. The red specimens included one each from the back of two mature Herefords. The white specimens included one from a mature Hereford and one from a mature Holstein. The hair on the white Hereford specimen was somewhat wooly and fine compared to that on the white Holstein specimen. The fawn specimens were from the back and upper neck of a Jersey cow.

Sol-air temperature measurements were made during midday and afternoon on seven clear days between August 4 and 21, 1953. Readings taken at times when pryheliometer traces were unduly broken due to scattered clouds were discarded. From the observed values of t_e, t_o, and I, values for b/f_{cro} were computed. These computed values of b/f_{cro} and the observed wind velocities were subjected to co-variance analysis to test the differences among the means of sol-air temperatures for the four colors of hair adjusted for wind velocity. These means were adjusted according to a straight-line regression of b/f_{cro} on wind velocity. Differences among the adjusted means were found to be significant at the 1 percent level.

Statistical analysis was made to test the differences among the regressions of b/f_{cro} on wind velocity for each of the four colors. This analysis yielded an f value nonsignificant at the 5 percent level. Thus it appears that under a given combination of solar radiation and ambient air temperature, increases in wind velocity will be accompanied by about the same decrease in b/f_{cro} for each of the colors of cow hair. However, the sol-air temperatures will be different under a given set of conditions for different colors of hair.

A graphical representation of b/f_{cro} vs. wind velocity for each of the four different hair colors is shown in Fig. 5. As would be expected, the lighter colored hair coats have markedly lower sol-air temperatures. The fawn colored specimen from the Jersey cow was noticeably slick and smooth, with the hairs lying close to the surface, whereas the other specimens had more or less up-standing hair. Stewart (6), in extensive studies of reflectance of hair samples removed from cattle, found that orientation and smoothness were not a factor in reflectance. Therefore, it is probable that the difference between fawn and white b/f_{cro} values is due to differences in f_{cro} values.

The values of b/f_{cro} obtained can be used to estimate the sol-air temperatures for cattle under various combinations of ambient air temperature, solar irradiation, and wind velocity. For example, consider a day when the outdoor temperature is 97 F, solar irradiation on a horizontal surface is 250 Btu per sq ft hr and the wind velocity is 200 fpm (approximately 2¼ mph). Applying the expression for sol-air temperature

$$t_e = \frac{b}{f_{cro}} I + t_o$$

we obtain for a horizontal, black hair surface a sol-air temperature of 152 F; for red, 152 F; for white, 144 F, and for fawn, 132 F. When it is recalled that the sol-air temperature is that to which the ambient air should be heated to produce the same heat transfer to the surface completely shielded from radiation as actually exists under the given conditions, it is evident that the white and fawn surfaces have considerable advantage as low heat gain surfaces when exposed to strong solar irradiation. It should be kept in mind that only a limited area of a cow standing outdoors would be so oriented that these maximum sol-air temperatures would exist.

The effect of a breeze can also be demonstrated. With the same solar irradiation intensity and ambient temperature as before, but with a breeze of 800 fpm (approximately 9 mph), the sol-air temperatures will be reduced to 142 F for black; 141 F for red; 133 F for white; and 121 F for fawn. Thus, the beneficial effects of breeze on surfaces of cattle exposed to strong solar irradiation can be evaluated.

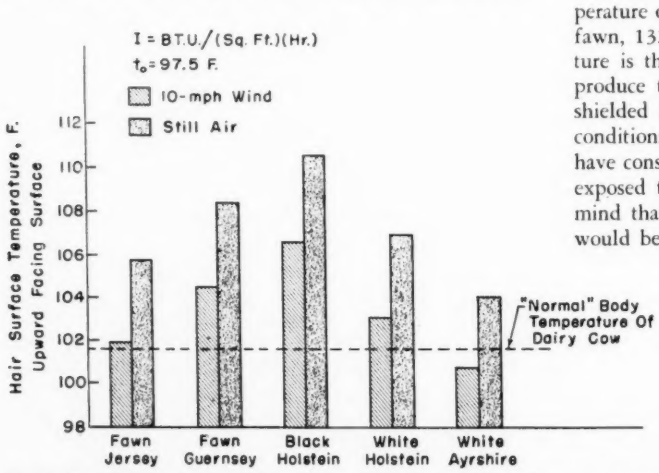


Fig. 6 Comparison of hair-surface temperatures under hot-weather conditions, upward-facing surfaces

The foregoing analysis provides an approach toward evaluating heat gain to irradiated surfaces of unsheltered cattle during hot summer weather, but does not measure the temperature response of surfaces of live cattle to sol-air temperature. In order to study the response, surface-temperature measurements were made on dairy cattle. These measurements were made on 4 cows on six selected days in the period July 3 to August 20, 1953. The cows included a Guernsey, Jersey, Holstein, and Ayrshire, all of which were lactating and received no shelter from trees or structures during the summer. Surface temperatures were measured on the loin at three points reasonably close together for the Ayrshire (white), Jersey (fawn), and Guernsey (fawn). Temperatures were measured at three points on the loin (black) of the Holstein and at three points on the rump (white). In each case, one set of (3) readings was taken on the hair surface and one set on the skin by parting the hair. A 20-gage iron-constantan thermocouple junction on a prong-type holder modeled after one described by Thompson(7) was used together with an electronically balanced potentiometer for measuring the temperatures. Air temperatures and wind velocities were measured during each group of surface-temperature readings.

These air temperatures and wind velocities were used, together with pyrheliometer data for solar irradiation on a horizontal surface to compute sol-air temperatures for the hair surfaces of live cattle on which temperatures had been measured. The regression expressions previously developed were used for computing b/f_{cro}, which was then used for computing t_e. The resulting data on surface temperature, t_s, versus computed sol-air temperature, t_e, were then subjected to covariance analysis to test for differences among the means of t_s adjusted for t_e for the three colors. This covariance analysis yielded the following information:

For differences in temperatures on skin surface of cows due to differences in

Breeds (Guernsey and Jersey) within fawn color ..... f non significant at 5 percent level

Breeds (Holstein and Ayrshire) within white color ..... f significant at 1 percent level

Breeds and colors ..... f significant at 1 percent level

For differences in temperatures on hair surface of cows due to differences in

Breeds within fawn color ..... f nonsignificant at 5 percent level

Breeds within white color ..... f significant at 5 percent level

Breeds and colors ..... f significant at 1 percent level

The regression expressions obtained for b/f_{cro} on wind velocity were combined with those obtained for hair-surface temperature, t_{sh}, on t_e to give the following expressions for upward-facing hair surface temperatures of each of the breeds and colors for any given combination of outdoor wind velocity, v, feet per minute; ambient temperature, t_o, and solar irradiation, I:

Fawn Jersey—

$$t_{sh}=72.3+0.0381\ I-1.77\text{x}10^{-5}vI+0.2461\ t_o$$

Fawn Guernsey—

$$t_{sh}=74.9+0.0381\ I-1.77\text{x}10^{-5}vI+0.2461\ t_o$$

Black Holstein—

$$t_{sh}=72.0+0.0581\ I-1.77\text{x}10^{-5}vI+0.2461\ t_o$$

White Holstein—

$$t_{sh}=70.6+0.0497\ I-1.77\text{x}10^{-5}vI+0.2461\ t_o$$

White Ayrshire—

$$t_{sh}=68.2+0.0497\ I-1.77\text{x}10^{-5}vI+0.2461\ t_o$$

The principal information to be obtained from the foregoing expressions is the relative effect of the factors of color, wind velocity, outdoor temperature and solar irradiation on hair-surface temperature. Results of a series of computation for hair-surface temperatures under assumed conditions that are fairly typical of a hot day in Oklahoma are diagrammed in Fig. 6. These indicate that air movement is of about as much importance as a light color in reducing surface temperatures. Furthermore, it is likely that the beneficial effects of increasing wind velocity will extend over a larger area of the cows body than is involved in high intensity solar irradiation, especially when the air temperature is lower than the cow's surface temperature.

SUMMARY

Analysis of heat gain to surfaces of buildings and livestock under summertime conditions indicates that the sol-air temperature concept has value as an index for comparing different surfaces as to their effectiveness in reducing heat gain; and as a basis for correlating heat gain with varying conditions of solar irradiation intensity, wind velocity, and ambient temperature.

Two sol-air thermometers which differed in construction details were built and used for measuring sol-air temperatures of surfaces of concrete masonry, metal roofing, and cattle. An analysis of the probable errors due to imperfect insulation of the specimen from heat transfer from the reverse side indicated that with reasonably good insulation, errors would probably not exceed 1 deg. Furthermore, if a temperature measurement is made within the thermometer, a calculation can be made to correct for the error.

Sol-air temperature measurements of six different kinds of concrete-masonry surfaces were correlated with heat gain through twelve kinds of concrete-masonry construction in the west-facing wall of a cooled livestock shelter. Sol-air temperature measurements of three kinds of metal roofing, including enameled steel, weathered aluminum, and weathered galavanized steel were made and analyzed to yield values for a coefficient that could be used in computing sol-air temperatures under other conditions. Sol-air temperatures of the galvanized steel and aluminum surfaces were correlated with temperatures measured on corresponding roofing in place on the south slope of a typical livestock shelter.

Sol-air temperatures were measured for cattle surface specimens that included red, white, fawn, and black. These data were subjected to covariance analysis and coefficients were developed for computing sol-air temperatures under various weather conditions. Surface temperatures were measured over an extended interval of time on upward-facing surfaces of four cows under outdoor, hot-weather conditions. A covariance analysis was made for the regression of surface temperature on sol-air temperature to test for differences due to breed and surface color.

(Continued on page 645)

Short Method of Surveying for Small Open Ditches

George S. Vasilakes

THE farmers in central Minnesota are increasing the farmable acres of their land by draining the thousands of potholes that are scattered on their farms. These low areas are often less than ½ acre. As most of them lie on high land as small depressions between knolls, they make good farm land. Although the potholes are usually small, often the large areas surrounding them are too wet to be worked. Since this wet land is impossible to farm, farmers spend extra time and money going around them.

To encourage farmers to drain their land by land-conserving methods, the U.S. Soil Conservation Service offers them free technical advice. The farmers also receive a small payment for each cubic yard of ditch that conforms to SCS requirements. The farm planner of a district is the SCS representative. At the farmer's request he surveys the farmer's land to determine whether the pothole can be drained. After the contractor finishes the ditch, the farm planner again runs a line of levels on the ditch to make sure it has the proper grade and dimension. If the ditch meets the requirements, the farm planner authorizes payment to the farmer.

In Becker County, Minnesota, farmers drained their potholes faster than the farm planner could survey them. To speed up his work, so that more farmers could drain their land, the farm planner developed the "short method" of surveying for small open ditches.

In developing this method, the farm planner knew that the ditches were usually short and drained only small potholes. Since the machinery used in that area required a 6-ft bottom and at least 4-to-1 sideslopes, the ditches were in most cases overdesigned. As the ditches through necessity were too large anyway, all he had to do was to get a proper grade on the ditch to drain the pothole. By using the short method of surveying he could determine the grade, calculate the cuts and fills, and place the stakes in the ground—all in one operation.

In comparison, the standard method of surveying, which is most commonly used, requires a quick preliminary survey to determine if drainage is possible. If the land is drainable, the farm planner makes a second, more complete survey. Afterwards, he takes his notes to the office and draws a profile of the land to determine the grade of the ditch. Since the farm is often several miles away, the farm planner usually waits until the next day to mark the required cuts and fills on the stakes.

In making a survey by the short method, the levelman sets the instrument between the pothole and the proposed outlet. The rodman first holds his rod at the outlet for the levelman. Then he goes to the center of the pothole and places the rod at the lowest point. The levelman compares this rod reading to the outlet rod reading. If the outlet is much lower than the pothole and the distance between them is short so that the center of the pothole is drainable, the levelman records the rod reading under F.S. at station 0+00 (Fig. 1). If the pothole is large or deep, the levelman starts the ditch with a 1-ft cut in the center. As many of the potholes are small he often uses a 0.5-ft cut.

When getting the signal from the levelman, the rodman marks the stake C 0.5 and places it near the rod. In this case, the levelman reads 5.0 ft as a foresight (F.S.), he adds the 0.5-ft cut to the 5.0 ft to get the grade rod (Rod). Since there is enough fall, the levelman sets the ditch grade at 0.5 percent, so that at station 1+00 the grade rod is 6.0 ft. If the foresight is 4.0 ft, the cut is 2.0 ft. After the rodman marks the center stake with the required cut, he paces off 15 to 25 ft at right angles to the ditch's center line. This is the reference stake. By subtracting this foresight from 6.0 ft the levelman gets the amount of cut for the reference stake.

For station 2+00, the rodman paces off another 100 ft. Here they follow the same procedure in determining the cuts of the center and reference stakes as they did for station 1+00. If the difference in elevation between the bottom of the pothole and the outlet is great, the grade of the ditch bottom is likely to come to the surface before the outlet is reached. In this case the rodman paces off from the last stake, until the levelman signals him that the bottom of the ditch is 0.5 ft from the surface. The rodman marks the station and the cut for a center stake only. From this stake on to the outlet he marks the stakes for a 0.5-ft cut.

If the elevation between the outlet and the pothole is small and the distance between them is great, the levelman may cut the bottom of the pothole 0.5 ft and continue the ditch at a 0.25-percent grade. When he knows that the ditch has enough fall, he can change to the standard 0.5-percent grade. On some of the farms in the northern part of

Paper prepared expressly for AGRICULTURAL ENGINEERING.

John Breik — N½ NW¼ — Lake Park Twp

Sta	Rod	F.S.	Cut	F.S.	Ref Stake Cut
0+00	5.5	5.0	0.5	4.5	1.0
1+00	6.0	4.0	2.0	5.0	1.0
2+00	6.5	4.0	2.5	3.0	3.5
3+00	7.0	5.5	1.5	5.0	2.0
4+00	7.5	7.1	0.4	6.8	0.7
4+24	7.7	7.8	+0.1		

John Breik — N½ NW¼ — Lake Park Twp

Sta	Rod	F.S.	Cut	F.S.	Ref Stake Cut
0+00	5.5	5.0	0.5	4.5	1.0
1+00	6.0	4.0	2.0	5.0	1.0
2+00	6.5	4.0	2.5	3.0	3.5
3+00	7.0	5.5	1.5	5.0	2.0
4+00	8.3	7.8	0.5	7.0	1.3
5+00	8.8	6.8	2.0	5.8	3.0
6+00	9.3	8.3	1.0	7.3	2.0
7+00	9.8	8.8	1.0	7.3	2.5
8+00	10.3	8.8	1.5	8.3	2.0
TP	4.0 / 6.3	100 / 6.0 / 4.0			
9+00	6.8	5.8	1.0	4.8	2.0
10+00	~~7.3~~ 6.8	6.3	~~1.0~~ 0.5	5.8	~~1.5~~ 1.0
11+00	~~7.8~~ 7.3	6.3	~~1.5~~ 1.0	6.0	~~1.8~~ 1.3
12+00	~~8.3~~ 7.8	7.3	~~1.0~~ 0.0	7.0	~~1.3~~ 0.3

Fig. 1 *(Left)* and Fig. 2 *(Right)* Sample field data sheets

Becker County, the land is so level that the potholes cannot be drained completely. By starting the ditch level with the bottom of the pothole and continuing it at a 0.25-percent grade, the ditch drains most of the water out.

If there are several potholes in one field and it seems feasible that one ditch can drain most of them, the levelman takes a rod reading at the lowest part of the highest pothole. To get the grade rod, he adds the 0.5-ft cut to the foresight; that is, if the foresight is 5.0 ft, the grade rod is 5.5 ft (Fig. 2). At station 1+00 the grade rod is 6.0 ft, if the grade is 0.5 percent. At station 2+00 the grade rod is 6.5 ft. Since at station 4+00 there is another pothole, the levelman runs the ditch into it at any elevation above its lowest point. Depending on the fall, the depth, and the size of the pothole, he starts another ditch at a steep enough grade to drain this pothole into the next pothole, and so on to the outlet.

If at station 8+00, the levelman wants to make a turning point, the rodman sets the rod on a solid rock while the levelman takes a reading. After moving the instrument to its new position the levelman sights back on the rod. He takes the difference between the foresight and backsight and subtracts it from the grade rod (Fig. 2). This is his new grade rod. To continue on with the ditch he increases the grade rod 0.5 ft every 100 ft until the ditch reaches the outlet.

In a very few instances the levelman finds that he misjudged the fall to the outlet, so that the ditch bottom comes below the outlet. Since the rodman marks the cuts on the reference and center stakes as he proceeds to the outlet, each stake has its assumed cut. If, for example, the ditch bottom is 1.0 ft below the outlet, the levelman changes the ditch's grade to 0.25 percent as far back as he finds it necessary (Fig. 2) In this example, he changed the grade to 0.25 percent from station 10+00 to the outlet. Since he changed the grade, he had to go back to stations 10+00 and 11+00 to change the cuts on the stakes.

The "short method" works surprisingly well. The levelman easily learns to judge when to change the ditch grade in response to the changing conditions. As it allows him to do all his calculations in the field, he can start surveying just ahead of the contractor—and remain ahead.

Hot Weather Shelters for Livestock

(Continued from page 643)

CONCLUSIONS

In studies of heat gain to building or animal surfaces, it is important to analyze the surface characteristics that influence convective heat transfer from the surface as well as those that influence heating of the surface by solar and other irradiation. The two characteristics are not independent insofar as net heating effect on the surface due to solar irradiation is concerned.

Sol-air temperatures and sol-air thermometers appear to be useful tools for studying surface characteristics that affect summertime heat gain. The sol-air thermometer offers possibilities for obtaining information on the b/f_{cro} factor in a simplified definition of sol-air temperature. The values of this factor will differ somewhat depending upon whether the surface faces upward or horizontally, because the coefficient of convective heat transfer will be affected by attitude with respect to vertical.

A sol-air thermometer should be so constructed that the backing of the sample has low thermal capacity and high thermal resistance. Edge losses from the specimen to the thermometer should be minimized. Lack of perfect insulation can be corrected for by measuring temperatures at interior points in the thermometer.

Correlation was found to exist between sol-air minus interior air temperatures and maximum heat gain through concrete masonry block. Painting the exterior surfaces of concrete masonry walls exposed to solar radiation, as in west-facing walls, results in a marked reduction in maximum heat gain. Temperatures of the under side of metal roofing are closely correlated with sol-air temperatures.

The b/f_{cro} factor for cow surfaces is significantly different for the different colors, red, black, fawn, and white. This factor appears to be affected both by the color and texture of the surface. A light color, and smooth, glossy coat produced the lowest values of the factor b/f_{cro}. The b/f_{cro} factors appear to vary inversely with wind in the same manner for all samples.

Temperatures of upward-facing surfaces on cattle are correlated with sol-air temperatures. For such surfaces, the wind velocity across the animal can be just as important as color in reducing surface temperatures, especially for surfaces subjected to strong solar radiation when surface temperatures will be considerably higher than air temperatures.

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Formal education has first to make young people see that the values they have absorbed almost automatically from their culture are not necessarily the highest values. Young people must become dissatisfied with the culture they accept and this is why it is necessary first to start revolutions in their minds and spirits. . . The true business of liberal education is greatness. It is our task not to produce "safe" men, in whom our safety can never in any case lie, but to keep alive in young people the courage to dare to seek the truth, to be free.
—NATHAN MARSH PUSEY, president of Harvard University.

Mechanism of Ground Water Recharge

George A. Whetstone

THE planned recharging of underground reservoirs by diversion and control of surface sources is a relatively modern development. Among the earliest promotions of a recharge program which have come to the author's attention is that proposed in 1903 for the waterworks of Amsterdam, Holland (1)*. Here the rather limited sand beds which had been pumped for municipal supply since 1851 were suffering from salt-water encroachment. Surface water of adequate quantity, but highly polluted, existed in some canals. By spreading canal water on natural filter beds it was possible to drive back the salt-water interface, and to supply the municipality with pure ground water.

A paper in a Bavarian technical journal in 1904 (2) described the basic concepts of artificial recharge with the comment that it was "well understood in Sweden."

These may or may not be the earliest discussions and applications of recharge; they are certainly not the earliest studies of ground-water problems.

Artificial recharge has been actively studied and practiced for some years in California, Utah, and elsewhere. The usual pattern in localities where recharge is an economic success has been to spread flood waters from a stream over the debris cone which has formed at the point of emergence from the mountains. Such cones are nearly always highly pervious and, being at the heads of their valleys, can absorb large quantities of water which drains into the subsoil of the entire lower basins. Frequently such valleys are nearly watertight; it is then a simple matter to organize the political and economic machinery necessary to pay for the dams, canals, desilting basins, wells, and other works incidental to the diversion and control of the recharge water.

Sporadic attempts at recharge have also been made in areas such as the High Plains of Texas by drilling recharge wells in lake bottoms and by building low dams across arroyos. Silting has taken a heavy toll. Surface water has not always been available for the spreading. The liklihood of recapture by the organization paying the costs of recharge has not been too good. In short, the results so far have indicated a dubious economic feasibility.

In such circumstances, the next logical step in seeking a solution is to examine the fundamental physical elements of the processes by which moisture finds its way from the atmosphere to the water table.

Here we find ourselves in a field of hydraulics or, more accurately, hydropneumatics which has not received nearly as much attention from scientists as has the flow of fluids in pipes, channels, or saturated permeable media. Enough is known, however, to indicate that the basic laws of hydraulics —such things as pressure head equals depth from liquid surface, discharge equals area multiplied by velocity, etc.— which, with reasonable interpretations, apply to the saturated portions of the soil below the water table, do not apply in the soil volume which the moisture must traverse in reaching the ground-water reservoir.

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*Numbers in parentheses refer to the appended bibliography.

To get an appreciation of the processes involved in this movement of moisture let us visualize some simple experiments.

Consider first a glass tube closed at the bottom by a close-mesh metal screen and then filled with fine-grained dry sand. If some water is poured in, it is found to wet a volume of sand at the top of the tube equal to about three times the volume of the water used. A sharp change in color marks the boundary between the wet and dry sand. By pouring the water in slowly and cautiously one may induce this boundary to advance to within a quarter-inch of the screen. The tube may then be set aside for days without a single drop of water running out.

Returning to the tube after some days we find that much of the top sand will have dried out by evaporation. To produce flow we must replace these losses as well as supply water for the dry quarter-inch we had left at the bottom.

Once flow through the screen has been produced it will be observed that dripping continues for some time after the water supply has ceased. Thus a sand for which 35 percent of its volume in water was required to start flow may drain down to where it holds only 30 percent. If, after this draining has ceased, a few drops of water be added at the top, the same quantity will almost immediately drain out the bottom.

An interesting variant is to add a little ink at the top. The same amount of clear water will promptly drain out. If now water be slowly added, it will be necessary to supply about five-sixth as much water as the sand can hold before any tint appears in the effluent. Shortly thereafter the color becomes very strong and then fades quickly. This would indicate that all the moisture in the soil, even that in most intimate contact with the grains, participates in the downward motion in its proper turn. The same condition does not hold with gravel or very coarse sand; here paths of least resistance exist through which some of the ink drains rather promptly.

As a consequence of this failure to drain except under a surface covered with standing water, it follows that it may take years for a particle of moisture to move from the surface to the water table. When the surface is dry, water in the root zones can be lost only by evaporation or transpiration. In a capillary soil it cannot flow down by gravity alone.

Thus if recharge is to be promoted, surface flow to pools of some sort must be encouraged. The best recharge areas are frequently found in permeable land at the foot of relatively impermeable slopes. The effect on ground water of a single hard rain which is concentrated in such an area by surface runoff may be greater than would result from several years of natural precipitation on a similar surface without the flow from adjacent lands.

It might be well to examine our natural recharge areas in the sand hills with this point in mind. Can their drainage to points of concentration be improved with little expense?

Several series of experiments by the French botanist Jamin in 1860 in connection with the rise of sap in tall trees have some implications for recharge which seem to have been overlooked in ground water studies (3).

As the culmination of his experimental program Jamin made a completely non-organic tree well over 34 ft tall which absorbed moisture in its roots, lifted it up the trunk and evaporated it from the leaves by capillary effects alone without pumping of any sort.

To study the mechanics of such capillary phenomena in their simplest elements he took a small-bore glass tube about a meter long and attached one end to a vacuum pump. With a good flow of air established from the atmosphere to the vacuum, he oscillated a damp cloth into and out of contact with the free end of the tube very rapidly. This created a series of liquid indices in the tube separated by air bubbles. At first the liquid indices climbed the tube very rapidly but as more indices formed the velocity dropped off and ultimately all motion stopped. A tube prepared in this manner has some interesting properties.

If one exerts a pressure at one end, the indices close to that end move away rapidly; those not so close move but little; and many indices at the far end are completely unaffected. Moreover, if a pressure of amount p causes motion in the first n bubbles, a pressure of $2p$ would cause motion in the first $2n$.

Conversely, a vacuum at one end causes the bubbles near that end to dilate considerably. Bubbles farther away dilate less, and those beyond some nth bubble are unaffected.

These experiments have shown that, in a cylindrical tube, each liquid index has some limiting pressure drop, L, which it sustains before moving. After equilibrium has been reestablished, the pressure in the first few bubbles from an end which has had its pressure raised to p would thus be p-L, p-$2L$, p-$3L$, etc., until some bubble was reached at p-nL such that its pressure was less than a full step, L, above the pressure at the far end. All other bubbles would be unaffected.

Limited Pressure Drop Found to Be Independent

The limiting pressure drop, L, has been found to be independent of the length of the liquid index, to increase as the air bubbles become smaller, and to increase very rapidly as the tube diameter decreases. In a tube which would support a capillary rise of 200 mm, L has been found to be 54 mm. Thus four interruptions will balance the capillary lift in this case. In other words, four bubbles of air would suffice to hold 400 mm of water in the tube against gravity.

If a capillary passage has a varying cross section with narrow "bottlenecks" separating wider portions, as, of course, channels in the soil grains do, its behavior is still more curious.

The passage having been filled and drained, a film will have remained in contact with the walls after the first emptying. This moisture will soon collect into a series of liquid drops in the necks thus forming a Jamin tube spontaneously. These tubes of irregular cross section are even more effective for pressure damping than are the cylindrical tubes. Jamin has reported an instance where only eight bubbles were required to hold a pressure of two atmospheres.

If such a tube is full of water and a liquid pressure is exerted at one end, flow takes place. If, on the other hand, a gas pressure is exerted at one end, the water is driven out of one chamber after another successively, always leaving a liquid index at each neck. If enough such necks exist, flow will cease.

In another series of experiments Jamin showed that, if an earthenware pitcher be surrounded by air, water placed in it would ultimately filter out through the pores in the walls. Immediately after it is empty, however, the pitcher could be subjected to a vacuum without having air enter through these same pores. If both inside and outside of the pitcher are in water and a gas pressure be exerted on the inside, it will drive all the water out of the vessel. Thereafter two, three, or even four atmospheres may be held without any air bubbles escaping through the pores.

The implications of Jamin's experiments for practical ground water recharge seem clear enough.

1 Alternate wetting and drying of the recharge zone should be avoided in order that as little air as possible be present in the soil. In practice this would favor recharge by wells reaching below the water table rather than by spreading in a basin unless the basin could be kept wet continuously.

2 Water carrying silt should not be used for recharge since the silt filters out narrowing the "necks" in the percolation tubes. Silt, of course, is detrimental also for its property of reducing the total voids in a soil volume by lodging in the interstices of the existing larger-grain structures.

Economic Handling of Silt is Difficult

In practice, the economic handling of silt is difficult or even impossible. In the debris-cone installations previously referred to, recourse has been had to desilting-basins in which the stream flow is impounded for a period before being released to the spreading basins. The silt which remains after the period of impounding has been observed to deposit as a thin skin almost like a layer of paint. By plowing the desilting basin while an inch or two of water remains in it, the pores are reopened to water without admitting air.

It is possible to clean wells but, except in places like Long Island, New York, where clean water which has served for air-conditioning cooling is reintroduced into the ground to help hold back salt-water encroachment, it is doubtful if it is economically feasible. This seems, however, to be a point on which study should be focused in some other areas.

In addition to the purely physical factors already discussed, some chemical and biological aspects of recharge have been found to have marked influence with certain types of soil(4). Thus, hard water percolates more freely than soft, and a high sodium content in the water has been found to be detrimental to recharge.

Plant growth on the recharge area may serve two important purposes in that it may increase the rate of percolation over what it would be for bare ground and may provide a forage crop during the off-season for recharge, thus improving the efficiency of land use. In a series of tests in California(4) it was found that Bermuda grass was ideal for this purpose since it thrives under two or three inches of water if the blades are long enough to project above the water surface, it is drought resistant for the long off-periods, it is self-seeding, and it is an excellent grazing plant.

Much of the falling off of the rate of recharge with time has been traced to the action of soil bacteria. After a period of forty to sixty days of continuous submergence it is usually beneficial to allow the recharge area to dry out through the top six to eight inches and then resume the recharge.

Of all the various expedients tried to date — chemical treatment of the water, plowing, raking, or scraping of the recharge area; drilling of auger holes to be filled with

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Feed Grinding with Electric Motors

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Report on Performance and Electrical Load Characteristics of 5-hp Motors and Grinders

BETWEEN the years 1930 and 1950, the number of man-hours required to raise one acre of corn were reduced by 41.5 percent. During the same period the man-hours required to care for a dairy cow were reduced only 5.8 percent, and those required to produce 100 pounds of pork, 15.4 percent.

One reason for this difference in labor reduction between crop and livestock production is the lack of mechanization in animal production. Feed handling and processing is one element in the livestock labor that can be mechanized to help reduce the man-hour requirements. The development of handier, more powerful tractors, more efficient feed grinders, and more versatile conveyors has already reduced labor to some extent. However, much of the time spent in handling feed is used in setting up the machinery for grinding and in loading, transporting, and unloading grain rather than in the actual grinding. Conflicting demands on the tractor for field and chore operations require planning and timing that are often upset by the weather.

Many attempts have been made to eliminate this setup, transport, and handling time by designing an integrated feed-handling system centered about an electrically powered grinder. While some of these efforts have been successful, the problem of grinding ear corn with an electric motor that could be operated on a single-phase rural electric line has been a major obstacle.

In the past few years, concentrated effort has been directed toward the successful application of a 5-hp single-phase motor to feed grinding. A research project on this subject conducted by the Illinois Agricultural Experiment Station was based on the assumption that, because of the low hourly capacity of a 5-hp-driven grinder and the resulting inefficiencies in use of the operator's time in hand feeding a small grinder, the entire operation must be automatic. This study has been reported at previous ASAE meetings and in AGRICULTURAL ENGINEERING.

During the course of the Illinois research, many different grinder and motor combinations were tested. Wide variations in capacity, dependability, and power demand were found to exist both in the laboratory tests and in the more than ten field installations that were made. Some of the factors causing these variations were:

- Condition of grain
- Setting of adjustments and controls
- Power supply and farm wiring problems
- Grinder and motor design.

Little can be done to change grain condition other than to impress on the operator the importance of clean picking and proper moisture from the standpoint of quality as well as grinding ease. However, the other three factors can be controlled. Controls and adjustments can be simplified and more adequate instructions can be given for machine operation. Power supply and farm wiring needs can be met after exact needs are determined. Grinder and motor design can be improved, and the best combination of grinder and motor can be used if manufacturers, dealers, and farmers are all informed regarding the problems.

Farmers have long been aware of the fact that types and designs of grinders vary widely in capacity and power consumption. On this basis each farmer has selected the grinder that worked best with his tractor. On the other hand, he has usually selected his motor on the basis of price or convenience, since, to his knowledge, any 5-hp motor will satisfac-

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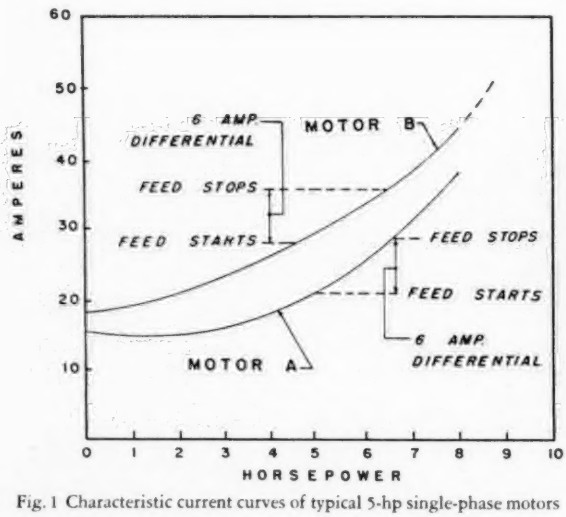

Fig. 1 Characteristic current curves of typical 5-hp single-phase motors

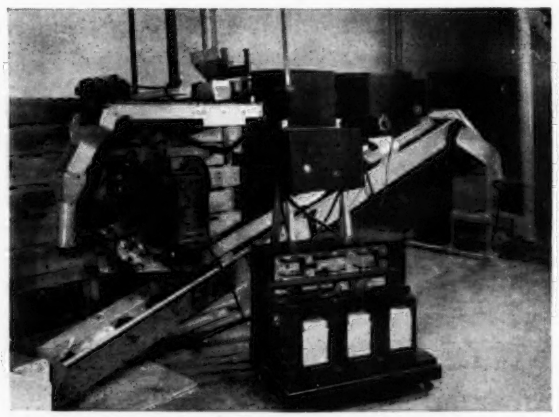

Fig. 2 Laboratory test apparatus used in the Illinois research study of different feed-grinder and electric-motor combinations

torily operate a fan or elevator that is rated as a 5-hp load. The satisfaction obtained from such equipment is seldom contingent on the performance characteristics of the motor.

Grinding ear corn automatically with a 5-hp electric motor, however, introduces a new aspect in the selection of electric motors because performance characteristics do play an important part in the satisfactory operation of the machine. The effect of motors with different electrical load characteristics in combination with grinders of varying performance characteristics was therefore studied in a series of laboratory tests at the Illinois station. These tests were augmented by field tests made on several farm installations.

A routine system for testing the motors and grinders was established and variables were eliminated so that results could be duplicated in repeat tests. The fact should be emphasized, however, that the objective of these studies was to get information about the differences in electrical load characteristics *on* grinder performance rather than to make a comparison between the various types of motors and grinders.

During the course of the study, twelve grinders and ten motors were tested. Ten of the grinders were hammer mills, one was a burr mill, and one was a cutter-head type that ground through a screen. The motors included one repulsion-induction start and run; four repulsion-start, induction-run; two capacitor motors—one capacitor start and run and one capacitor-start, induction-run (all 1800 rpm); and three 3600-rpm repulsion-start, induction-run motors. Some of these motors and grinders were experimental designs that were not yet available on the market.

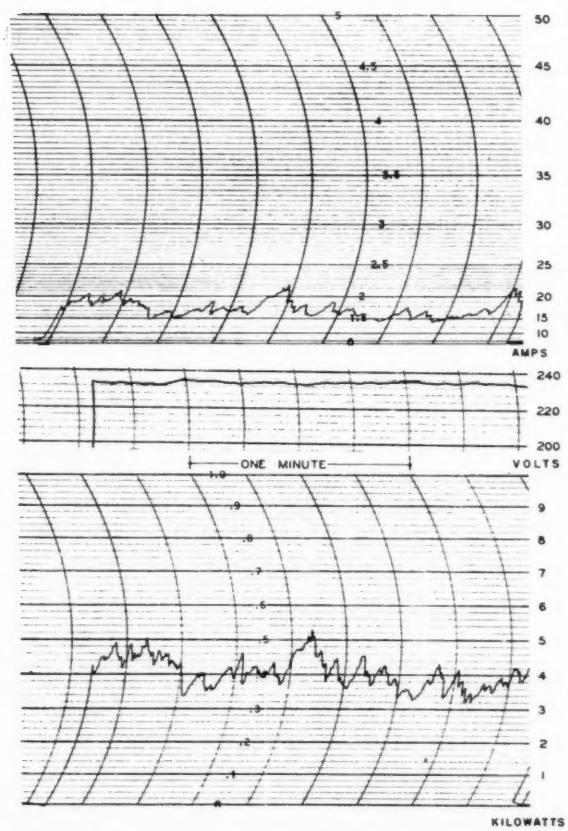

Fig. 3 Unusually low and uniform current and power curves were obtained with the cutterhead mill. The automatic electric controls were not activated since no overload fluctuations exceeded 25 amp

Records of the tests were taken on three Esterline Angus instruments linked together for synchronized reading of watts, volts, and amperes. A Jagabi recording hand tachometer, scales, stop watch, Ro-tap screens, and other similar equipment were also used for the tests.

Performance was judged by visual observation of the Esterline Angus charts in conjunction with an analysis of the frequency, severity, and duration of overload conditions and energy consumption per hundred pounds of feed ground. The most important motor operating characteristics are the maximum current during normal grinding and the length of time in severe overload. High currents, even though momentary, create voltage drop and resultant light flicker throughout the line. Prolonged and severe overloads cause high power demands, heating in fuse boxes, and overloads on normally satisfactory transformers and wiring.

Results of Mill Tests

Throughout a series of preliminary tests of automatic ear-corn grinding, one motor appeared to have more desirable electrical performance characteristics than others. This motor was used as the "base" for the grinder tests.

Variations in capacity of different grinders when used in the automatic ear-corn installation ranged from 170 to 538 lb per kw-hr. The mill with the highest capacity did not exceed a load of 25 amp during the tests. The mill with the lowest capacity had the most frequent and severe overload—14 percent of the time it drew 40 amp or more and 31 percent of the time it drew between 30 and 40 amp.

Results of Motor Tests

After the tests had been completed and the results compared, the grinder showing the most desirable load characteristics was used as the "base" mill for the tests of the electric motors. (The mill with the highest capacity and with a current demand not exceeding 25 amp was not used as the base because it was not satisfactory for grinding oats.) Because of the differences in normal rated current, the method of analysis used in the grinder tests could not be applied. Visual comparisons of the charts were made to determine differences in motor characteristics.

While the differences between different grinders and different motors were significant, the most important point brought out by these tests was the different results that can be obtained by using various *combinations* of mills and motors. This fact is illustrated in the following table:

RESULTS OF USE OF COMBINATIONS OF LEAST AND MOST SATISFACTORY MILLS AND MOTORS

	Capacity, lb per hr	Current surges, amp
Least satisfactory mill with least satisfactory motor	915	Over 100
Least satisfactory mill with satisfactory motor	1125	Up to 60
Satisfactory mill with satisfactory motor	2000	Up to 38
Most satisfactory mill (for grinding ear corn) with most satisfactory motor	2000	Under 25 at all times

Results of Field Tests

Detailed electrical load studies were made on five test-farm installations that were part of the research program. The objective of these tests was to find out how the labora-

tory results compared with actual farm performance. Since four of the installations had the same make of mill, motor, controls, and component parts, the tests from these farms served to indicate the range of performance that could be expected with different grains and management.

In general, the performance on the test farms was very good. The most serious problem was neglect to which the equipment had been subjected. In most cases little attention had been given to routine lubrication, mechanical adjustment, belt tension, replacement of worn parts, and cleanliness. On some of the motors, accumulations of grain, dust, and husks had almost completely blocked off the air vents.

Conclusions

1 Mills of several types can be made to operate automatically with an electric motor, but the capacities of some models are quite low and the severe load fluctuations of others are not desirable on rural electric lines.

2 Low-inertia, swinging hammer mills had the most desirable load characteristics of several types of mills tested.

3 The cutter-head mill, operated at low speed, had very good capacity and the best electrical load characteristics of any mill tested for grinding ear corn. However, it had a very low capacity in grinding oats for hog rations. This mill exhibits qualities that appear to justify further study of its application in the field of automatic operation.

4 Desirable grinder performance characteristics are *(a)* a grinding and *ground-feed-removal* capacity capable of absorbing the full output of a 5-hp motor without plugging the grinding chamber or the ground-feed-conveying system, *(b)* ability to receive ear corn at varying rates without transmitting the impact of each individual ear back to the motor, and *(c)* immediate transmission of severe overload back to the driving motor, where it can be controlled to prevent further overloading.

5 Desirable grinder design features include *(a)* ready accessibility and simple maintenance features for belt shields, belt-tension adjustment, and lubrication; *(b)* lifetime lubricated bearings wherever possible, and *(c)* clean operation and minimum leakage of ground feed and dust.

Motor characteristics that were found to be most desirable were a low rated-load current (high power factor) and a relatively low current under severe overload. A characteristic current curve with a gradual and uniform slope up to rated load and as low a locked rotor current as possible is more effective in an automatic-control system than a curve that is nearly flat to rated load and then curves steeply upward to a high locked rotor current. In areas where rural power rates are based on demand charges, it would pay the farmer to buy a motor with low-demand characteristics even if it costs more.

Repulsion-induction motors have been generally recommended as the most suitable for such farm loads as feed grinding. On the basis of laboratory tests alone, it appears that recent developments in capacitor motors may make them equally as good as some repulsion-induction motors, or even better, for automatic grinding.

Motor designs should include features that will permit a minimum amount of service and maintenance and protection against rodents, loose grain, and dust. It does not appear practical or necessary to demand fully enclosed or explosion-proof motors at this time.

Field observations made during these tests, as well as results of the entire project, emphasize the importance of rugged, foolproof construction, good protective devices, and explicit operating instructions. The more nearly automatic the machine, the greater the tendency to neglect regular maintenance.

The results of this study show how wide a range of performance and electrical loads can be imposed on farm wiring and rural lines. Combinations of good mills, good motors, and good designs make for customer satisfaction and desirable load. However, poor management of good equipment or a poor combination of equipment can result in inefficient operation as well as create an electrical load that will be almost intolerable. Successful combinations of good equipment and good management can be brought about only through the education of everyone concerned. Equipment suppliers must be familiar with the problems of the farmer and the power supplier. The farmer must be aware of the problems created by high current demands and severe load fluctuations. The power supplier must decide what electrical loads the line can tolerate and must make this information known to users. Only through such cooperation will it be possible to achieve the most satisfactory results.

Ground Water Recharge

(Continued from page 647)

gravel; covering of the ponds with tarpaper to exclude sunlight; vegetative plantings with many different test plants; maintaining of various heads of standing water over the recharge area; desilting, and treating of the recharge area by the addition of organic matter — this latter has been found to be the most effective. In fact, by the use of cotton-gin waste, infiltration rates of several times those of undisturbed soil have been obtained.

If the gin waste is dumped on the ground or, preferably, plowed in, just before spreading starts, its beneficial effect is delayed for several weeks. If, on the other hand, the waste is plowed in, then kept moist for thirty days, and finally allowed to dry out thoroughly before spreading is begun, its effect on percolation is immediate. It has been reported(4) that an application of this sort made in 1946 was still beneficial in 1950.

In many prairie areas the timing of a spreading season cannot be predicted with the assurance possible where spreading water is furnished by the flood flows of streams fed by the mountain snow-melt. With the long effective life reported for treated spreading areas elsewhere, however, it would seem that local experimentation would produce an optimum pattern for the treatment of some of the lake beds or other selected spreading areas of such regions.

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In Situ Measurement of Soil Bulk Density

James A. Vomocil

New Method of Rapid Measurement by the Gamma Ray Absorption Technique

IN EVALUATING tillage methods and soil management practices, measuring traffic effects, and locating impermeable layers for design of drainage systems, some means of making rapid measurements of bulk density of soil is desired. Present methods require excessive time and labor and cause undesirable plot disturbance in making measurements below the plow layer. In this paper a method is proposed that does not require the removal of a large sample. It takes advantage of the properties of a radioactive material for measuring purposes.

Theory of New Method

Energy transmission through a medium depends on the type of energy involved and on the physical and chemical properties of the medium. But transmission of a small range of the gamma energies produced in nuclear reactions involves only one property of the medium. These are transmitted through a unit thickness of soil in inverse logarithmic proportion to its density in accordance with the Beer-Lambert law

$$\frac{I}{I_o} = e^{-ux} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

in which I_o is the initial intensity of the energy beam, I is the intensity of the beam transmitted through a thickness x, and u is a factor proportional to the bulk density of the soil. This $u = \sigma d$, where σ is the mass absorption coefficient and d is the density. By judicious selection of photon energy, σ can be made independent of chemical composition, although it varies some with the density, as will be explained later.

Gamma ray energy is absorbed by photoelectric effect, Compton effect, and pair production. Photoelectric effect and pair production are negligible for energies slightly over 1 mev. Since absorption by Compton effect is proportional to A/Z, where A is the atomic weight and Z is the atomic number, it is essentially constant for all elements except hydrogen to about $Z = 30$ in the periodic table. This range ($Z = 2$-30) includes everything found in appreciable amounts in soils. Hence we may say that absorption is independent of the chemical composition for these energies (Table 1).

TABLE 1. ABSORPTION COEFFICIENT OF IMPORTANT MATERIALS AND ELEMENTS

Material	Absorption coefficient at 1.25 mev, $cm^2\ gm^{-1}$	Reference
Water*	0.055	4
Air	0.054	4
Aluminum	0.058	4
Silicon	0.057	3
Iron	0.057	4
Calcium	0.058	5
Magnesium	0.058	5
Sodium	0.055	3
Potassium	0.056	3
Concrete†	0.055	4

*Agreement of the coefficient for water with those of the other elements indicates that, in some molecules, hydrogen has a negligible effect.

†Concrete is included here to illustrate the principle that mixing various materials having similar absorption coefficients yields a product having a like absorption coefficient.

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The author—JAMES A. VOMOCIL—is research assistant, department of soils, New Jersey Agricultural Experiment Station.

Author's Note: Acknowledgment of suggestions and contributions is due G. D. Brill, project supervisor, soils research branch, U. S. Department of Agriculture, and G. R. Blake, assistant research specialist, New Jersey Agricultural Experiment Station. Since this paper was prepared and presented, R. K. Bernhard and M. Chasek, college of engineering, Rutgers University, to whom the author is greatly indebted for encouragement and for many helpful suggestions, have published a paper, "Soil Density Determination by Means of Radioactive Isotopes" in *Nondestructive Testing* 11(8): 17-23, November-December, 1953.

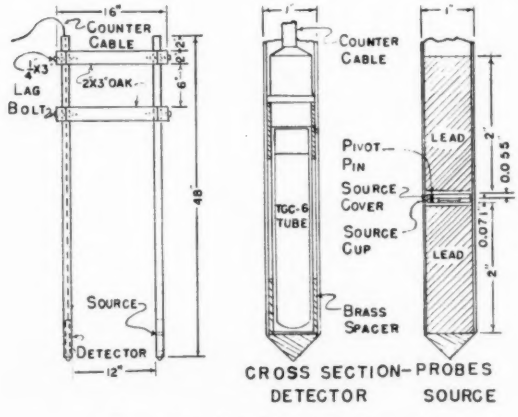

Fig. 1 Assembly of the soil-density probe

Fig. 2 Equipment for calibration of soil-density probes

Density determination based on this theory requires only a source of suitable gamma radiation, a detector for this radiation, and a counting device. Cobalt 60,* a relatively inexpensive radioisotope, is an ideal source. It decays with a dichromatic radiation of 1.16 and 1.32 mev. Absorption of these energies was studied by Davisson and Evans (2)† and found satisfactory for the conditions cited above. Cobalt 60 has a half life of 5.2 years, so at the end of each month a given quantity of it has an output equal to about 99 percent of that at the beginning of the month, making correction for decay very small.

The detector and counting systems are subject to few limitations. A portable survey meter, calibrated in counts a minute, is a satisfactory counting device. The associated detector should be small enough to fit into a small probe and sturdy enough to stand field handling. It should be interchangeable so that the system need not be recalibrated in case of replacement. Any small-diameter Geiger-Mueller tube with a short active portion is satisfactory.

The source and detector must be rigidly fixed with respect to one another because, as shown in equation [1], the transmittancy is as dependent on distance as on density. There are two methods in which these can be arranged in the soil. In one, details of which have been worked out by Belcher (1) and others, both are placed in the same tube and separated by a shield of lead. Radiation from the source passes into the soil and a portion of it is scattered back to the detector. In the other the source and detector are placed in separate tubes with the soil sample between them, the tubes being so fixed together that the distance between them remains constant.

The one-probe system depends on scattering between the source and detector. These are necessarily separated by several inches of lead in the probe, so the average density of an 8-10-in layer of soil is measured. Density cannot be measured within 6 in or so of the soil surface because of radiation loss. For some purposes these are minor faults, but in dealing with soil they become serious limitations. The two-probe system makes it possible to reduce the thickness of the measured layer to 2 or 3 in and to measure density within about 3 in of the surface. The second method was chosen for this work.

Construction of a Two-Probe Instrument

The probes, shown in Fig. 1, were 1-in (outside diameter) aluminum tube with a wall thickness of 0.064 in. They were fastened together near one end by two lengths of 2 x 3-in oak wood so the distance between them was $12 \pm \frac{1}{64}$ in.

The cobalt 60 (one millicurie in May, 1953), consisting of an 8-mm section of 1-mm wire contained in a hollow aluminum wafer about the size of a quarter, was housed in one probe. A second wafer, pivoted to the first by an off-center rivet, served as a lid. By making this container as thin as possible and tightly fitting 2-in-long plugs above and below it in the probe, it was possible to provide some collimation of the beam toward the detector, shield personnel, and prevent movement of the source in the probe.

* Cobalt 60 used in this experiment was supplied by the Oak Ridge Laboratories on authorization from the isotopes division, U. S. Atomic Energy Commission. Handling of the isotope and control of health hazard was under the supervision of S. J. Toth, New Jersey Agricultural Experiment Station.

† Numbers in parentheses refer to the appended bibliography.

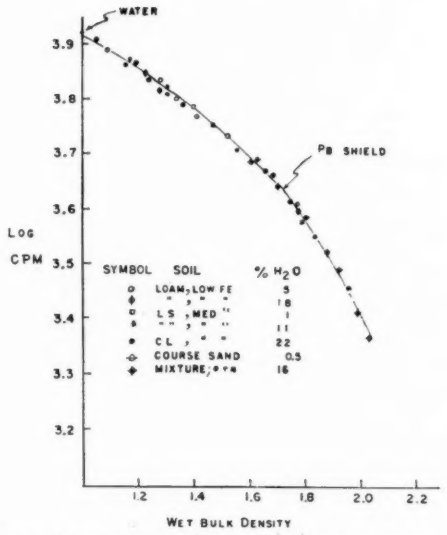

Fig. 3 Transmission of gamma ray intensity through soil

The other probe contained a Tracerlab TGC-6 Geiger-Mueller detector tube in a P-17 side-window shield with a 10-ft coaxial cable. The outside diameter of the P-17 was 0.870 in, so it fit snugly into the probe yet allowed it to be removed for transport and storage. A brass bushing was fitted to the end of the side-window shield opposite the tube socket to provide a better fit into the aluminum probe.

The counting instrument was a Tracerlab SU-5A survey meter.

Calibration

Though the theory predicts the intensity of radiation transmitted through a soil of given density from a given source, certain phenomena made it necessary to calibrate the system against soils of known density before it was used. The absorption coefficient, σ, is determined for substances under conditions where only the direct beam is considered, but in practice scattering of the beam occurred. This changed the quantity of radiation passing to the detector. Consequently, in measuring the density of a soil, its transmittancy was compared to that of another soil of known bulk density.

The calibration was made in a steel cylindrical tank 16 in in diameter and 30 in deep. Two aluminum tubes with inside diameters of 1.1 in and wall thicknesses of 0.035 in were fixed in this tank so that the probes could be lowered into them. The tank was filled with soil of bulk density determined by its mass and volume. The combined cross-

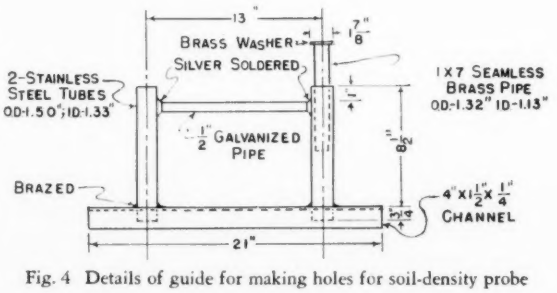

Fig. 4 Details of guide for making holes for soil-density probe

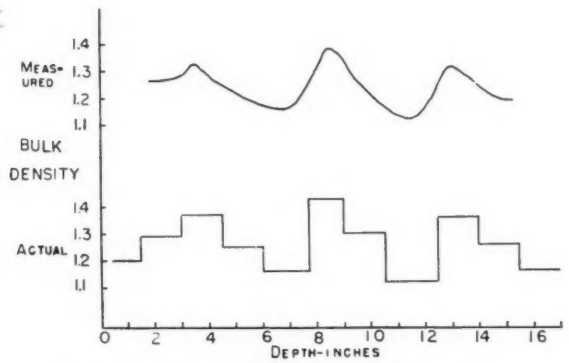

Fig. 5 Effect of sample thickness on density measurement

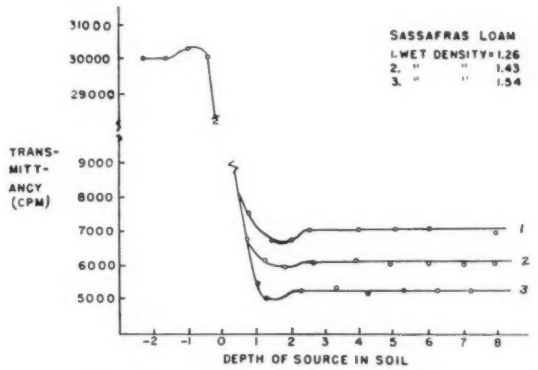

Fig. 6 Effect of soil surface on transmittancy

sectional density of the guide tubes was only 0.58 gm cm^{-2}, compared to a total of 40-60 gm cm^{-2} for the soil, so their effect was small and constant. Correction for this factor was easily calculated. The arrangement for calibration is shown in Fig. 2.

Transmittancies of a number of soils at varying bulk densities and moisture contents were determined in the calibration chamber. The gamma ray intensity transmitted was plotted against wet bulk density (Fig. 3). Since the rate of decay of radioisotopes varies randomly, only the average rate over a period of time has precision. Counting rates were determined by taking 8 readings of the meter at 15-sec intervals. The average had a probable error of ± 1.5 percent.

It is to be particularly noted that wet density, i.e., the weight of a unit volume of soil plus moisture, is the property that determines transmittancy. Fortunately water has about the same absorption coefficient as other soil materials.

Wet density plotted against the log of transmitted intensity did not yield the straight-line equation [1] predicted. The curvature implied that σ was not constant for the particular geometric arrangement employed here but increased with increased density. Absorption coefficients such as those tabulated are corrected for scattering and secondary emission effects. The coefficient calculated from a curve such as the one given would result from effects of direct-beam, scattering, and secondary emission. Changes in ratio of scattering and secondary emission to direct-beam intensities could conceivably result in increase in σ with increase in density. Presumably this increase should be proportional to the density; i.e., the second derivative of the curve would be constant. Analysis of the curve indicated this was nearly true, but a sharp change in the second derivative occurred at a wet-bulk density of about 1.75—1.80. No explanation for this behavior is offered.

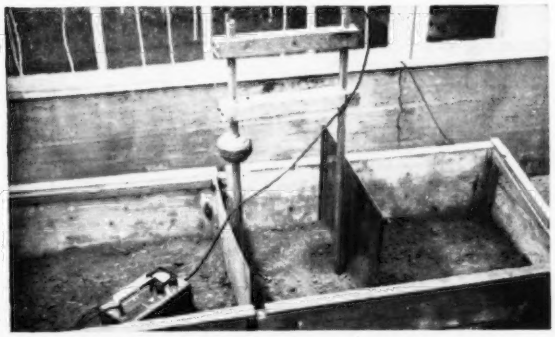

Fig. 7 An arrangement for the determination of border effect

Field Use of Instrument

For field use, two properly sized holes, spaced 12 in apart and parallel to one another to 4 in below the desired depth of measurement, were made. The soil from these holes was saved for moisture determination so that wet densities could be corrected to dry-bulk densities. The probes were then lowered into the holes until the source was at the desired depth of measurement, a series of counts was recorded, and the average of these was compared on the calibration graph for conversion to wet-bulk density.

For purposes of spacing and aligning the prepared holes, a guide (Fig. 4) was used. This guide, constructed for use with a Veihmeyer tube, consisted of two stainless steel tubes with inside diameters of 1.334 in and wall thicknesses of 0.083 in welded to a channel iron 4 x 1½ x ¼ x 21 in. The guiding tubes were welded into holes in the large flat surface in such a manner that they were perpendicular to this surface and exactly parallel to one another, with about 1 in protruding in the concave side of the channel. The over-all length of the guide tubes was 10 in. At the end opposite the channel iron, the tubes were silver-soldered to a length of ½-in galvanized iron pipe that served as a brace to maintain alignment and as a carrying handle.

Inside diameters of the guiding tubes were established at the selected size in order to accommodate the swollen head of the Veihmeyer tube. Whereas the diameter of the Veihmeyer tube itself was 1.125 in, that of the head used was 1.250 in. The 0.08-in difference between the head diameter and the inside diameter of the guide was more than necessary clearance but was controlled by availability of materials. A brass bushing, turned from 1-in seamless red brass pipe (outside diameter = 1.315; inside diameter = 1.063) was used between the Veihmeyer tube and the inside of the stainless steel guiding tube. Clearances of 0.006 and 0.008 in were allowed between the bushing and the guide, and the guide and the Veihmeyer tube, respectively. These were found satisfactory when precaution was taken to keep the sliding surfaces free of sand particles.

The Veihmeyer tube used to make the holes also served to bring up soil cores from the several depths for moisture determination and mechanical analysis. Moisture measurement was necessary because transmittancy is proportional to

wet density, but dry density is a better measure of compactness. Wet and dry-bulk densities of soil are related in the following manner:

$$\text{Dry bulk density} = \frac{100 \times \text{wet bulk density}}{100 + \text{percent moisture dry-weight basis}}$$

The symbols D_b and D_{bw} are suggested for bulk density and wet-bulk density, respectively.

A lead shield, described later, rested on the soil surface to support the probes in the proper position. Readings could be made at any depth desired, subject only to length of probes. A strong rubber band tied around the probe prevented its slipping down through the shield.

Effect of Sample Depth and Thickness on Transmittancy

As previously mentioned, the one-probe system has the disadvantage that thin sections of soil cannot be accurately measured and the upper limit of measurement is about 6 to 8 in below the soil surface. To ascertain to what extent the two-probe method overcame these difficulties, many trials were made with the source at various depths from the surface and with various thicknesses of soil at one density sandwiched between layers of different density. About 2 in was the thinnest layer that could be accurately measured with the geometry employed. The nearest the source could be to the soil surface for accurate measurement was about 2½ to 3 in (Figs. 5 and 6). The length of the active portion of the TGC-6 Geiger-Mueller tube used for a detector was 2½ in. If it had been longer, both limits would have been greater.

Layers less than 2 in thick were detectable but their densities were not accurately represented, the measurement being an average of the densities of the given layer and of those above and below it for short distances. Layers more than 2 in thick were accurately represented.

Border Effects in Calibration and Accuracy

It will be recalled that the distance between probes was 12 in, the diameter of each probe was 1 in, and the diameter of the calibration chamber was 16 in. Because of the scattering that is known to occur, a question arose as to the error involved in the use of the small calibrating chamber. Possibly the iron walls of the chamber and the outside air reflected radiation in a manner sufficiently different from what would occur in the field that an error in calibration would result.

To investigate this, a different calibration chamber was constructed consisting of a wooden box 2 x 2 x 7 ft. The box was made so that steel plates could be inserted perpendicularly to the length in two positions, cutting the box into three compartments, A, B, and C (Fig. 7).

The center compartment B, was made 16 in wide to simulate the condition of the calibration cylinder. This compartment was filled with soil, compartments A and C contained air, the probes were positioned along a line parallel to the length of the box, and transmittancy was determined. Compartment A was then filled with soil, while both iron plates were left in position and the transmittancy of B was determined. This transmittancy did not differ from that recorded when compartment A was empty. The same was true when compartment C was filled and when one or both steel plates were removed from the soil. The differences in counting rates due to differing border conditions were all less than the probable error of measurement.

As a further check, the transmittancy method for bulk density was compared to the conventional 3-in core-sampler method in the field (Table 2).

TABLE 2. BULK DENSITY BY TRANSMITTANCY COMPARED TO CORE-SAMPLER METHOD

Soil	Bulk density by core sample	Bulk density by transmittancy
Nixon loam subsoil	1.63	1.60
	1.62	1.60
	1.48	1.47
	1.65	1.62
Sassafras loam	1.12	1.14
	1.36	1.33
	1.44	1.42

Changes in the System with Time

As already mentioned, intensity of radiation from the source decreases with time. With cobalt 60 this decrease was slow but appreciable during a summer. Certain other changes occurred that made it advisable to recheck the calibration of the instrument at least once a month. Principal among these was the decrease in battery voltages in the counter. Pulses from the Geiger-Mueller tube were amplified and stored until sufficient power was available to drive a signaling device. For a portable counter, three sets of batteries were necessary; filament voltage, B+ voltage, and a high voltage for operation of the Geiger-Mueller tube. The batteries did not all run down at the same rate and not always in the same manner. The change in counting rate with time was, therefore, a complex function that was most readily checked and compensated for by frequent recalibration. The lead shield and a container of water, using the same container and same depth each time, were found to be convenient materials for use in continuing calibration of the system. When changes occurred, the same correction factor was used over the entire length of the curve.

Radiation Hazard

The radiation hazard was extremely low because of the small quantity of radioisotope used and the short-time intervals it was near the user. A spherical lead shield (Fig. 2), formed by turning from a cylinder of lead and boring along a diameter, was used to cover the probe containing the source when it was out of the soil. The walls of the shield were 1½ in thick. This, together with the 2-in lead plugs below and above the source in the tube, was sufficient to attenuate the radiation flux to a level permissible for 40 hr a week exposure at a distance of 1 ft from the source. It is improbable that anyone would stay this close to the source for this period of time. Film badges worn during development and extensive field use of the instrument indicated no detectable radiation.

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Moving Feed from Storage to Feeding Point

R. W. Kleis
Assoc. Member ASAE

Results of Research on Design Requirements of Grain and Ground-Feed Pneumatic Conveying Systems

ON AN ideally arranged farmstead of a livestock farm, there would be no problem in moving grain and ground feed from the storage-grinding area to the feeding point. These two areas would be close enough together to permit spouting or conveying the feed by means of short conveyors to the feeding point. On most livestock farms, however, the arrangement is not ideal, and much time and effort are required to handle and transport feed.

The general development, over the past few years, of farmer interest in reducing labor and increasing production efficiency in livestock feeding has created a demand for equipment to perform chore operations mechanically. Because preparing and handling of feed is one of the most labor-consuming operations on the livestock farm, it is logical that much interest and attention has been given to it. It is significant to note that most of the previous work on grain handling has been directed either toward improving methods and equipment for handling and processing grain in the storage and processing area of the farmstead or to the actual feeding operation. Little attention has been given to the problem of moving feed from the storage area to the feeding point. On many farms a pneumatic grain conveyor is an answer to this problem. The research reported in this paper was carried on in order to determine the design requirements of penumatic conveying systems for moving grain about the farmstead.

Any of several different types of conveyor systems can be used to handle various materials. To convey grain and ground feed from the storage building to the feeding area, however, blowers have several obvious advantages over most mechanical conveyors which utilize augers, belts, or chains. Some of the significant features of a pneumatic system are:

- Construction is simple. The fact that there is only one moving part minimizes servicing and maintenance.
- The directing mechanism consists of sheet steel pipe, which is readily available and relatively inexpensive.
- The system is flexible and can include turns.
- The pipe is light and can be suspended overhead, out of the way.
- The system can be made weatherproof.

One apparent disadvantage of penumatic conveyor systems is that they are somewhat less efficient than mechanical conveyors so far as power demand is concerned. This disadvantage is, however, more than offset by their lower original cost.

In planning a pneumatic grain-conveying system, consideration must be given to such things as desired conveying rate, pipe size, pipe length, blower size, blower speed, power required, pipe arrangement, and air velocity. Some of these factors, such as conveying rate and pipe length, are fixed for any given installation. Others, however, must be determined according to their relation to these fixed conditions.

Only a limited amount of information has been available upon which to base the design of a pneumatic conveyor system. Many systems now in use, while operating satisfactorily, are not designed for most efficient use of power and equipment. It is believed that the results of this research should aid in the designing of less expensive and more efficient systems.

Paper presented at the 47th annual meeting of the American Society of Agricultural Engineers at Minneapolis, Minn., June, 1954, on a program arranged by the Rural Electric Division. The research reported in this paper was done as part of a general study of equipment and methods for automatic and mechanical grinding, blending, and handling of grain on a livestock farm. The over-all project is being carried on cooperatively by the Illinois Agricultural Experiment Station and the U.S. Department of Agriculture and is supported in part by the Illinois Farm Electrification Council. Project leaders are E. W. Lehmann and R. W. Kleis of the Illinois station and L. S. Foote of the farm electrification section, agricultural engineering research branch (ARS), U.S. Department of Agriculture.

The author—R. W. KLEIS—is assistant professor of agricultural engineering, University of Illinois.

Procedure

About 150 separate tests were conducted in which various pipe sizes, pipe lengths, types of grain, blowers, con-

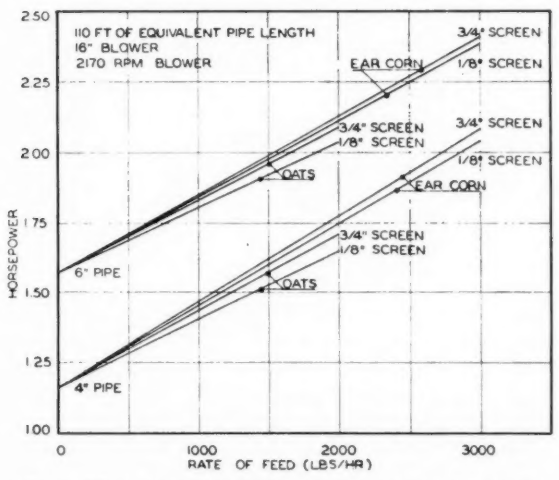

Fig. 1 Effect of type of grain, fineness of grind, and pipe size on power required

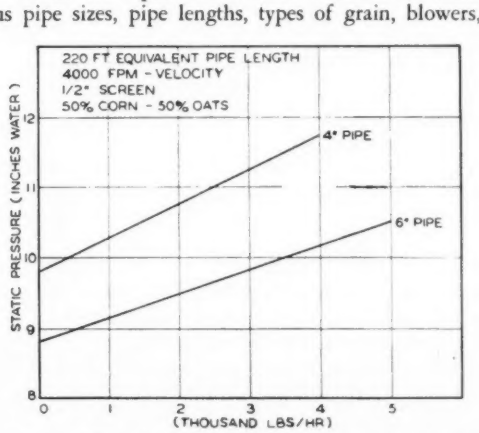

Fig. 2 Effect of pipe size and rate of feed on static pressure

veying rates, etc., were used. In all of them conventional instrumentation was used. An inclined-tube oil manometer was used to measure static pressures and also velocity pressure in conjunction with a pitot tube. A cradle dynamometer and recording tachometer were used to determine speed and horsepower. Other instruments included a stop watch, scales, rotap machine, and Kewanee grain meter for feeding the grain into the blower.

Air Velocity

An adequate air velocity is essential for trouble-free operation of a grain-conveying system. Both laboratory tests and field observations indicate that an air velocity of 4000 fpm is necessary and sufficient for satisfactory and continuous operation. Velocities as low as 3500 fpm have been found to be sufficient to convey grain so long as it is kept moving. However, such a velocity will not clean a conveyor pipe once grain has settled to the bottom, as would happen if the blower stopped for any reason when there was grain in the system.

The air velocity of a given system is determined by blower speed. The speed required to give a velocity of 4000 fpm depends on blower design, pipe size, and pipe length. The speed, then, can be obtained from the pressure characteristics of the pipe system and the blower curves if they are available. If these data are not available, the velocity will need to be measured and the speed adjusted accordingly.

Pipe Size

Nearly all of the existing conveyor installations consist of 6-in pipe, and many of them are conveying less than one ton per hour. Both theory and research indicate that smaller sized pipe is more efficient, from a power demand standpoint, when the amount to be conveyed is limited. The practical size range for conveying grain is 4, 5, and 6-in pipe. Which size should be used for a particular installation will depend on the amount to be conveyed in a unit of time. The practical limits of conveying rates for these pipe sizes are:

4-inch pipe—3500 pounds per hour
5-inch pipe—4500 pounds per hour
6-inch pipe—5500 pounds per hour

These conveying rates are not the absolute maximum; rather, they are practical limits that allow for slight variations in operating conditions.

The optimum pipe size for any given system is the smallest allowable for the desired conveying rate. As indicated in Fig. 1, for a given conveying rate the smaller pipe requires considerably less power. This fact is in line with basic fluid flow theory and is supported by the curves of Fig. 2, which are based on the test data.

So far as power requirements are concerned, the optimum pipe size for a pneumatic conveyor is not affected by system length.

Power Requirements

The power required for a given system conveying a given amount of grain is made up of three components:

The first component is the power required to deliver a desired air velocity against the pressure of the system when no grain is flowing. With a velocity of 4000 fpm, this power is approximately 1 hp per 100 ft of equivalent length of 4-in pipe and 1½ hp for each 100 ft of equivalent length of 6-in pipe. This power can be calculated from total system pressure and volume of air moved. Assuming a velocity of 4000 fpm, it is possible to calculate the volume of air moved. Static pressure can be obtained from handbook information on resistance of systems according to pipe size, length, fittings, and type of dust collector.

The second component is the power absorbed in accelerating the grain as it passes through the blower. This amount can also be calculated by means of basic physical relationships. It is constant and directly proportional to blower size and speed. Because speed is an inverse function of blower size, the acceleration power is nearly the same for all blowers, amounting to about ⅓ hp for each 1000 lb of grain moved per hour (Fig. 1).

The third component is the additional power needed to overcome static pressure caused by the grain carried in the air. This amount is relatively small compared with the power required to accelerate the grain. As indicated in Fig. 2, the increase in pressure, and therefore the increase in power, is about 5 percent for each 1000 lb of grain conveyed per hour. This figure was determined experimentally for different lengths of pipe, various types of grain, and various conveying rates.

As shown in Fig. 1, the increase in static pressure and horsepower caused by the grain varies to some extent, depending on density and particle size of the grain. Heavy and coarsely ground grain does require slightly more power than lighter and more finely ground grain. While these differences were consistent in all tests, they are believed to be relatively insignificant in the design of a system.

This study did not show any gain in efficiency from sloping the conveyor pipe in either direction. However, field experience indicates the desirability of sloping the pipe slightly in one direction or the other to facilitate drainage of moisture that accumulates from condensation or leakage.

Effect of Blowing on Grain

As might be expected, the blower reduces particle size considerably. (In all of this test work, the grain was metered directly into the blower.) Two series of tests were conducted to investigate the extent of reduction of particle size under different operating conditions.

Table 1 shows some typical results of blowing at different blower speeds. The particle size of the ground ear corn from each of the three mills was reduced considerably as it went through the blower. The size reduction increased in all cases as the blower speed increased. Of the three types of grinders used, size reduction was most severe in the corn ground with the knife mill. This difference might be attributed to the sharp and irregular particles of grain ground in this mill.

TABLE 1. Effect of Blower Speed on Particle Size Reduction (Conveying rate, 1000 lb per hr)

	Fineness modulus—ground ear corn		
	Hammer mill, ¾-in screen	Knife mill, ½-in screen	Burr mill
Before blowing	4.51	5.06	4.69
2000 rpm	4.22	4.67	4.38
2500 rpm	4.13	4.44	4.24
3000 rpm	3.92	4.17	4.14

(Continued on page 660)

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Air-Flow Meter for Crop Drier

J. B. MacDonald and C. P. Hedlin
Assoc. Member ASAE

A LOW-RANGE hot-wire anemometer was developed by Ontario Hydro for measuring air velocities over the surface of hay driers. The device is a self-contained direct-reading portable instrument capable of measuring velocities from 0 to 20 fpm. During the summers of 1952 and 1953 it was used successfully by the Ontario Agricultural College to check the efficiencies of several experimental installations and also by Ontario Hydro's consumer service division to determine faults in a number of private installations.

Design Features

To provide an instrument capable of measuring the low velocities encountered, the idea was conceived of designing specifically for the purpose an anemometer of the hot-wire thermopile type. Although the hot-wire thermopile is most sensitive in the range of low air velocities, it was necessary to increase the velocity before the air was passed across the hot-wire element, to obtain a suitable scale deflection on an indicating millivoltmeter. The effect was achieved by means of a transition section which increased the velocity by a factor of about 24. With this arrangement and with the thermopile circuit as designed, a true velocity of 20 fpm gave a deflection of more than 80 percent full scale on a 0-5 mv-range millivoltmeter.

Two views of the instrument constructed are shown in Fig. 1, and the basic circuit arrangement in Fig. 2. The hot and cold thermocouples are "piled" to produce a voltage difference which is applied directly to a millivoltmeter. Because the temperature of the heated thermocouple is a function of the velocity of the air stream, so also is the emf output of the thermopile. The air stream passes over both the cold and the heated thermocouple; thus the instrument is independent of the temperature of the airstream.

Manganin wire is used for the heater element because of its low temperature coefficient, high resistivity, and reasonably good resistance to corrosion. The element is energized by three 1½-v dry-cell batteries connected in parallel. Iron-constantan thermocouple was selected rather than copper-constantan because of its greater emf output and lower thermal conductivity.

A single rheostat is used to adjust the battery current and the zero setting of the indicating meter. By providing end caps for the thermopile cartridge to prevent air flow when the initial adjustment is being made, the need for a separate calibration circuit is eliminated.

Simple Calibration Method

Precise calibration of such a low-range instrument is difficult without resorting to a complicated aerodynamic arrangement. It was found, however, that for all practical purposes a sufficiently accurate calibration could be obtained by use of a small vane-type anemometer in conjunction with a stop watch. Static-pressure measurements served to establish that the true velocity of the air through the thermopile cartridge was not seriously altered by the presence of the vane-type anemometer. The smooth form of the characteristic curve (Fig. 3) indicated that calibration in the range below the capability of the vane-type anemometer could be determined by interpolation with practically no error. As

(Continued on page 660)

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The authors—J. B. MACDONALD and C. P. HEDLIN—are, respectively, engineer, research division, The Hydro-Electric Power Commission of Ontario, and lecturer, agricultural engineering department, Ontario Agricultural College.

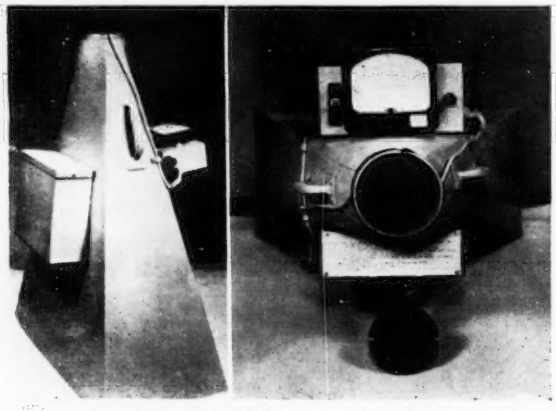
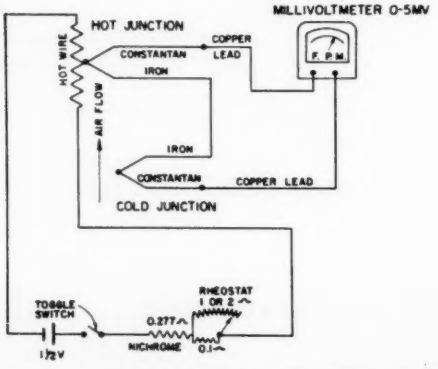


Fig. 1 Two views of the air-flow meter developed for use with crop driers



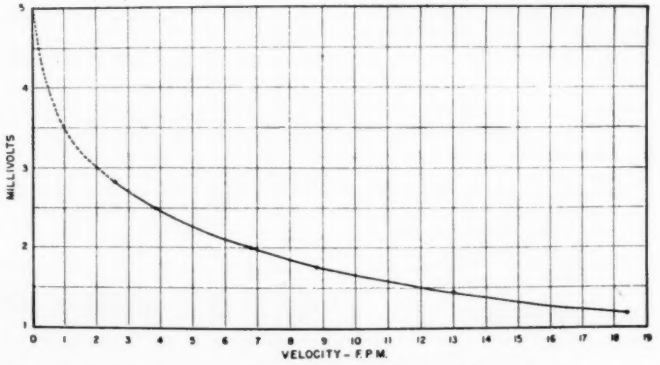


Fig. 2 *(Left)* Basic circuit arrangement of air-flow meter • Fig. 3 *(Right)* Calibration curve for the air-flow meter

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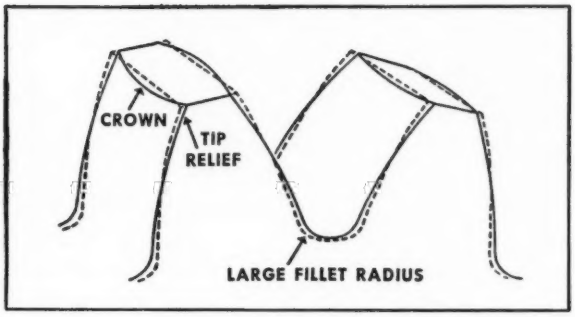
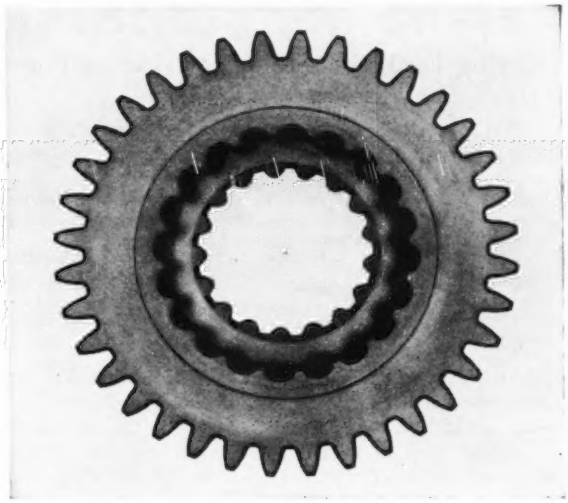


2nd, Tooth profile was redesigned by IH gear engineers. Radius of the tooth root fillet was increased. A slight "crown" was added to center the load evenly across the tooth face. Tooth profile was slightly modified, giving "tip relief" to prevent harmful interference as each tooth enters the mesh.



3rd, the gears were induction hardened—heat-treated by controlled audio and radio frequency waves—resulting in additional tooth strength to resist bending stresses, and hardness to resist wear. The high quality of the uniformly hardened "case" (dark outlines) permitted use of plain carbon steel instead of steel containing scarce alloys.

Increased horsepower enables the Farmall Super H to pull three 14-inch plow bottoms in average soils. Due to IH research, the transmission gears provide a greater margin of strength than in the two-plow Farmall H.

Air-Flow Meter for Crop Drier

(Continued from page 658)

previously mentioned, the zero point was obtained by blocking the air flow through the hot-wire thermopile cartridge.

The effect on the normal air flow from the hay surface of the air-flow meter transition section was determined to be insignificant. The reduction in the normal air flow was immeasurable and is estimated to be not more than 1 percent, which is less than the total instrument error.

Practicality Demonstrated

The instrument has proved to be very useful for checking the characteristics of driers for both baled and loose hay, and should also be valuable for testing grain driers. During the period of two years no serious corrosion of the thermopile wires has taken place, nor have breakdowns been experienced in the millivoltmeter or other components.

Moving Feed from Storage to Feeding Point

(Continued from page 656)

Table 2 illustrates the effect of conveying rate on particle-size reduction. The reduction decreases as conveying rate is increased. This difference may be attributed to the fact that at higher feeding rates a smaller percentage of the grain is subjected to direct impact with the blower blades.

TABLE 2. Effect of Conveying Rate on Particle Size Reduction (Blower speed, 3000 rpm)

	Fineness modulus—ground ear corn		
	Hammer mill, ¾-in screen	Knife mill, ½-in screen	Burr mill
Before blowing	4.51	5.06	4.69
1000 lb per hr	3.92	4.17	4.14
2000 lb per hr	3.99	4.32	4.25
3000 lb per hr	4.05	4.43	4.36

In the tests in which whole grain was used, it was observed that at least 50 percent of the kernels of shelled corn were broken by the blower. Blowing whole oats likewise resulted in a considerable amount of hulling. It is obvious, therefore, that such a system is not satisfactory for conveying whole grain unless it is to be fed immediately to livestock.

Separation of Grain at Terminal Point*

Separation of grain according to particle size as it is discharged from a conventional dust collector is often considered a disadvantage of blower systems. It was believed that this separation was more severe with blower systems than with other types of conveyors. Because of a lack of information, a series of tests was conducted to determine the actual degrees of separation as grain is discharged from blowers, belt conveyors, and augers.

In these tests grain was allowed to fall freely a distance of 40 in from the discharge point to a flat surface. Ear corn ground with a hammer mill through various sized screens was discharged from each conveyor and allowed to accumulate in the form of a cone until its vertex was 20 in high. Samples were then taken from equal concentric areas across the cone, and fineness modulus tests were run.

Large amounts of separation occurred in all tests involving various types of conveyors, different moisture contents and different finenesses of grind. The amount of separation decreased slightly as moisture content increased. Also, the finer the grind, the less the separation. Both of these results were anticipated. The significant conclusion, however, is that *there is little difference in the amount of separation from auger conveyors, belt conveyors, and blowers.* Separation was practically identical in the auger and the belt conveyor tests and only slightly greater in the blower tests. Differences caused by fineness of grind, moisture content, and conveying system were relatively insignificant compared with total separation in all tests.

Further work is now planned to study various designs of dust collectors and receiving bins that will minimize separation.

*This study was conducted by P. A. Konnecker as a special problem under the direction of the author.

Nailing Templates for Trussed Rafters

E. George Stern

THE widespread use of nailed trussed rafters and the benefit derived by using templates* for properly nailing trussed rafters led to the commercial production of such templates from sheet aluminum. Presently such nailing templates are available for trussed rafters of 24, 26, 28, and 30-ft spans with 3-in-12, 4-in-12, 5-in-12, and 6-in-12 pitches, as developed in the Wood Research Laboratory of Virginia Polytechnic Institute. Such templates will later become available for trussed rafters of larger spans.

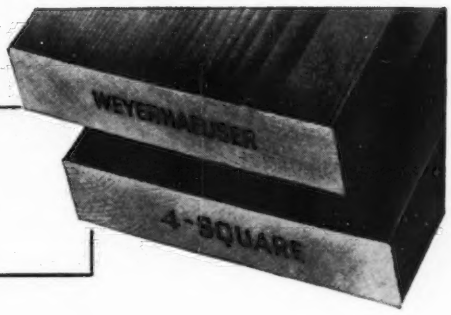
After completion of lumber cutting, the various trussed-rafter members are laid in the assembly jig. The templates are tacked to the top member of the respective joint and the nails are driven through the oversize openings provided as required on the basis of the design. Upon complete nailing, the templates are lifted over the nail heads and are ready for reuse.

Often more nail holes are shown than the number of nails required. Hence nails may not be driven where open knots, pitch pockets, local splits, and similar deficiencies can be seen through the template openings, since such nailing would make the nail ineffective or even degrade the lumber.

The author—E. GEORGE STERN—is research professor of wood construction, engineering experiment station, Virginia Polytechnic Institute.

*Reference is made to AGRICULTURAL ENGINEERING for July, 1954 (vol. 35, pp. 492, 495), where the advisability of using nailing templates is discussed. The commercial availability of such templates is the result of cooperative development work performed jointly by the Wood Research Laboratory, Virginia Polytechnic Institute and Virginia Aluminum Fabricators, Waynesboro, Va.

Nailing template for heel joints of nailed trussed rafter of 24-ft span and 3-in-12 pitch



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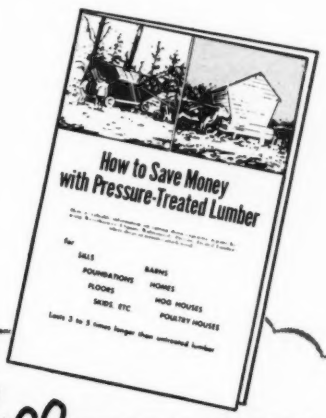

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Comparison of Soil and Water Majors in Civil and Agricultural Engineering Curriculums

A. J. Schwantes, P. W. Manson, and B. C. Colby
Fellow ASAE Member ASAE

SOMETIMES the graduate who has majored in soil and water subjects in an agricultural engineering curriculum finds that his qualifications for a position as a hydraulic engineer are questioned, even though a civil engineer with less academic background in hydraulics is automatically considered to be qualified. Obviously such a situation arises from a lack of knowledge of agricultural engineering curriculums.

Federal and private organizations, particularly the U.S. Geological Survey, are concerned with recruiting professional personnel for their investigational programs. At times difficulties and delays have been encountered before agricultural engineering applicants could be established on the same permanent competitive basis for hydraulic-engineering positions as are civil engineers. At a meeting in August, 1953, members of the Minnesota Water Resources Council of the Geological Survey decided to consult with the agricultural engineering department of the University of Minnesota with relation to this problem.

Subsequently the authors discussed methods of attacking the problem and decided first to collect pertinent data on the courses of study completed by graduates from both agricultural engineering and civil engineering curriculums. This information would, they believed, be applicable to the immediate need which prompted the action, and would have wide use in correcting the general lack of information which had resulted in such situations. The data, as collected and compiled, are presented here for the purpose of enabling agricultural engineers to establish their proper place in the fields of hydraulics and hydrology.

A form was prepared for compiling a comparative tabulation of academic credits for the agricultural engineer majoring in soil and water subjects, and for the average civil engineer. (A list of the basic and special subjects included in the form is given in Table 1.) Originally an attempt was made to separate elective and required courses, but this distinction was dropped in the tabulation and averaging of the data. The form was filled out for the University of Minnesota and this data together with blank forms, was sent to each of 20 land-grant colleges and universities having ECPD-accredited agricultural engineering curriculums, with the request that a similar tabulation be made for each school and a copy returned for use in the study reported here. Sixteen replies were received; however, since the reply from one university did not include many irrigation and soil courses, which are given at a location away from the main campus, an average of only 15 replies was compiled.

Table 1 shows the distribution of student effort among the various general classes of academic interest for agricultural engineering students majoring in soil and water subjects, and also for civil engineering students. The information given in the table should be quite representative of accredited agricultural engineering curriculums in general.

The study indicates that the academic background in basic subjects is practically the same for both groups of engineers. The agricultural engineers receive more training in the following special subjects:

Hydraulics, hydrology, water supply, drainage, and irrigation

Soils, geology, and agronomy

Mechanical and electrical engineering, mechanics and materials

General technical subjects.

The civil engineering curriculum emphasizes the following subjects:

Structures, concrete, highways, and railroads

Advanced surveying.

The civil engineering students have superior course training for the general fields of construction and mapping. Professional agricultural engineering students majoring in soil and water conservation, have a clearly defined advantage in their preparation for hydraulic engineering positions which involve the study of water supplies, soil and water conservation, irrigation, drainage, runoff, and other investigations of the hydrologic cycle.

TABLE 1. COMPARISON OF CIVIL AND AGRICULTURAL ENGINEERING CURRICULUMS EMPHASIZING SOIL AND WATER SUBJECTS

Basic Subjects	Semester Credits	
	Civil engineering	Agricultural engineering
Mathematics	17.63	17.76
English, writing, speaking	9.76	10.16
Physics	10.60	10.60
Chemistry	7.38	7.60
Drawing	6.05	5.69
General, nontechnical	16.71	16.36
Special Subjects		
Hydraulics, hydrology, water supply, drainage, irrigation, soil erosion, water conservation	11.18	13.66
Soils, geology, agronomy	5.04	10.41
Mechanical engineering, mechanics and materials, electrical engineering	16.06	20.42
General, technical	15.93	21.89
Structures, concrete, highways, railroads	20.78	8.58
Surveying	9.84	3.86
Civil engineering, total semester credits		146.96
Agricultural engineering, total semester credits		146.99

NOTE: Average figures are shown, based on data from 15 colleges having ECPD accredited agricultural engineering curriculums.

The authors — A. J. SCHWANTES, P. W. MANSON, and B. C. COLBY—respectively, professor and head of agricultural engineering department, professor of agricultural engineering, University of Minnesota, and hydraulic engineer, quality of water branch, U.S. Geological Survey.

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NEWS SECTION

President Nutt Represents Society

THE President of ASAE, George B. Nutt, head, agricultural engineering department, Clemson Agricultural College, represented both the Society and Clemson at the inauguration ceremony July 14 of Dr. Ben Hilbun as the new president of Mississippi State College, which incidentally, is Mr. Nutt's alma mater.

Mr. Nutt also represented the ASAE at the yearly meeting of the North Atlantic Section of the Society held on the campus of the University of Vermont at Burlington, August 24 to 26, where he was one of the principal speakers. After leaving Burlington, Mr. Nutt spent a few days at the ASAE central office in St. Joseph, Mich., and also visited the University of Illinois at Urbana to confer on arrangements for the 48th ASAE annual meeting which will be held there in June, 1955.

FEI 61st Annual Meeting

THE 61st annual meeting of the Farm Equipment Institute will be held October 20-22 at the Edgewater Beach Hotel in Chicago. Copies of the program and other information concerning the meeting may be obtained by writing the general offices of the Institute at 608 South Dearborn Street, Chicago 5.

Farm Electrification Conference in November

THE National Farm Electrification Conference will this year revert to the type of open meeting which has been followed in years past, and will be held November 18 and 19 at the Van Curler Hotel, Schenectady, N. Y. Inquiries concerning the Conference, including the program, should be addressed to NFEC Secretary R. J. Gingles, 155 East 44th St., New York 17, N. Y.

New Cotton-Ginning Lab

A NEW cotton-ginning branch laboratory for the Southeast was authorized recently when Congress made provision for it in the agricultural appropriation bill. The laboratory will be established at Clemson Agricultural College, Clemson, S. C. This branch laboratory was set up at Clemson because of its central and accessible location for service to all the southeastern cotton-growing states. The laboratory will be operated as a branch of the main USDA Cotton-Ginning Laboratory at Stoneville, Miss., which has been in operation for more than 25 years.

North Carolina Section Meeting

THE North Carolina Section of the American Society of Agricultural Engineers met at Camp Millstone September 7 to 9. The first day's program starting at 2:00 p.m. featured a panel discussion on latest developments in irrigation in North Carolina. Following a period for recreation in the late afternoon, including fishing, softball, volley ball, etc., a Section dinner was held in the evening with T. V. Wilson as master of ceremonies. The speaker for the occasion was L. H. Skromme, chief engineer, New Holland Machine Division, The Sperry Corp., and a vice-president of ASAE.

The entire day on September 8 was devoted to a field trip to McNair Farms at Laurinburg, N. C.

The program on the third day featured a panel discussion on furthering the service of the North Carolina Section. A Section business meeting was held following the panel discussion after which the meeting adjourned.

ASAE Meetings Calendar

October 1 and 2—ALABAMA SECTION, Gulf Shores, Ala.

October 7 and 8—PENNSYLVANIA SECTION, Allentown, Pa.

October 14 and 15—PACIFIC NORTHWEST SECTION, Davenport Hotel, Spokane, Wash.

October 23 — MICHIGAN SECTION, Agricultural Engineering Building, Michigan State College, East Lansing

November 4 and 5 — GEORGIA SECTION, Dinkler-Plaza Hotel, Atlanta, Ga.

December 6-8 — WINTER MEETING, Edgewater Beach Hotel, Chicago.

February 7-9—SOUTHEAST SECTION, Brown Hotel, Louisville, Ky.

June 12-15, 1955—48TH ANNUAL MEETING, University of Illinois, Urbana

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Agricultural Engineering in the USDA Reorganization

EDITOR'S NOTE: This statement is based on a talk by E. G. McKibben at a meeting of the ASAE North Atlantic Section at Burlington, Vt., August 24, 1954.

VARIOUS criteria have been used by different agencies and institutions to classify and organize agricultural programs, some of the more common being (1) *scientific disciplines*, as animal husbandry, field crops, soils, engineering; (2) *commodities*, as wheat, corn, cotton, and (3) *functions*, as production, marketing, utilization. Most administrators have found it impossible to work out a complete organization, however, on the basis of only one of these criteria; hence in the recent overhauling of the U.S. Department of Agriculture, some of the reorganization was effected on the basis of functions, some on commodities, and some on scientific disciplines.

Presumably those who had the responsibility for making the final decisions believed that they had arranged the most effective organization possible, all things considered, even though to many it may not seem logical in all details. Perhaps more important, however, than the logic of an organization is the effort of its members to make it work.

To show the relationships of agricultural engineering research to other activities of the Department, five outlines are appended. Outline I shows the U.S. Department of Agriculture divided into four administrative areas and into 16 services, administrations and corporations. Most of the agricultural engineering research in the Department is located in the two italicized services, that is, Agricultural Research and Agricultural Marketing Services, with the major part in the Agricultural Research Service. Outline II shows the Agricultural Research Service divided into research program areas and research and regulatory branches. Again the major part of the agricultural engineering research of the Department is in the two branches which are italicized, that is, the Soil and Water Conservation and Agricultural Engineering Research Branches. Outline III shows the division of these two branches into 10 sections. Three of the sections of the Soil and Water Conservation Branch, those italicized, employ an appreciable number of engineers, and the engineering phases of irrigation, drainage and hydrology are an important part of their programs. The five sections of the Agricultural Engineering Branch deal primarily with agricultural engineering research as indicated by the section titles. Outline IV shows the Agricultural Marketing Service divided into 13 divisions. One of these divisions, Marketing Research, employs a number of agricultural engineers. The research activities with which they are associated are shown by the italicized sections of Outline V. In some of these sections there are only one or two engineers employed. There may be other locations where one or more research engineers are employed, and there are a number of important units in the Department where agricultural and other engineers not primarily engaged in research are employed in considerable numbers, such as the Extension Service, the Soil Conservation Service and the Rural Electrification Administration.

OUTLINE I. U.S. Department of Agriculture — Secretary and Undersecretary

I Federal-States Relations — Assistant Secretary
- 1 *Agricultural Research Service*—Administrator
- 2 Forest Service—Chief
- 3 Soil Conservation Service—Administrator
- 4 Federal Extension Service — Administrator
- 5 Agricultural Conservation Program Service—Administrator
- 6 Farmer Cooperative Service—Administrator

II Marketing and Foreign Agriculture—Assistant Secretary
- 7 *Agricultural Marketing Service* — Administrator
- 8 Foreign Agricultural Service—Administrator
- 9 Commodity Exchange Service—Administrator

III Agricultural Stabilization—Assistant Secretary
- 10 Commodity Stabilization Service — Administrator
- 11 Commodity Credit Corporation — President
- 12 Federal Crop Insurance Corporation —Manager

IV Agricultural Credit — Assistant to the Secretary
- 13 Farmers Home Administration — Administrator
- 14 Rural Electrification Administration—Administrator

(Continued on page 674)

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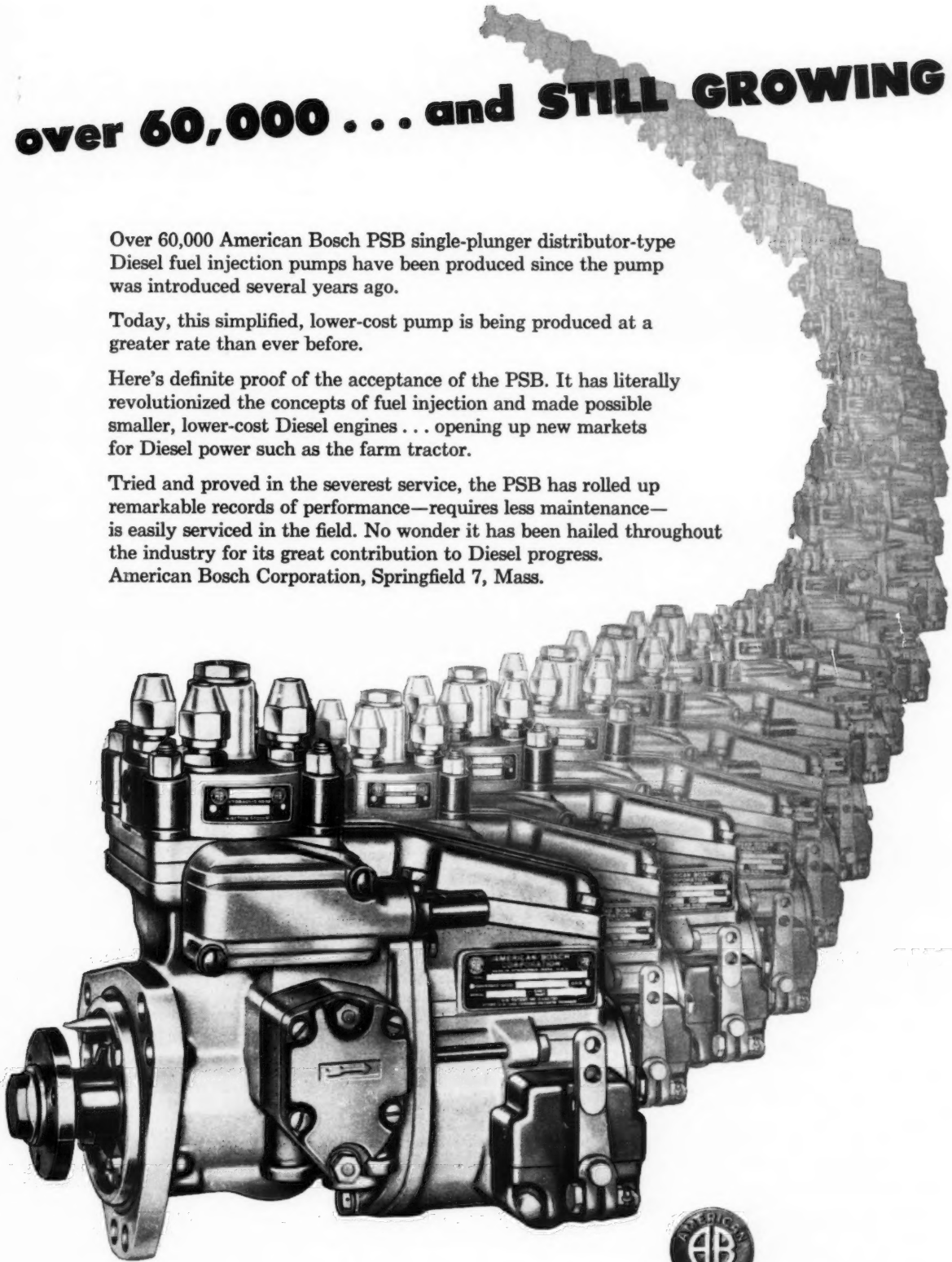

2402

AMERICAN BOSCH

NEWS OF ASAE MEMBERS

C. T. O'Harrow has resigned as assistant chief engineer, West Allis Works, Tractor Division, Allis-Chalmers Mfg. Co., to accept appointment as assistant chief tractor engineer, Tractor and Implement Division, Ford Motor Co. He will be located at Birmingham, Mich., where he will take an active part in establishing the major engineering center for tractors and farm equipment.

C. T. O'Harrow

Mr. O'Harrow is a native of Charles City, Ia., and is a graduate of Iowa State College in mechanical engineering. Upon graduation from college, he began his engineering career in his home city in 1927 as successively trainee, assembler, machinist and inspector for the Hart-Parr Co., now a part of The Oliver Corp.

Between 1928 and 1936 he was employed at the John Deere Waterloo Tractor Works, Waterloo, Iowa, as chief experimental engineer and assistant chief engineer. In the latter year he entered the employ of Allis-Chalmers as experimental engineer. He had completed 18 years of service with the company, attaining to the position of assistant chief engineer and in which position he was general administrative assistant to the chief engineer.

Mr. O'Harrow is a member of both the Society of Automotive Engineers and ASAE. He was vice-president of SAE representing the tractor and farm machinery division in 1953 and is currently a member of the Steering Committee of the Power and Machinery Division of ASAE. He has been a contributor to the programs of both societies.

J. C. Oglesbee, Jr., who for many years has carried the title of extension cotton ginning specialist in the Extension Service, U.S. Department of Agriculture, for the southeastern cotton-producing states with headquarters at Atlanta, has recently had his title changed, without change of duties or territory, to "extension agricultural engineer—cotton."

Jorge H. Rodrigues-Arias, head, agricultural engineering department, University of Puerto Rico, is presently on sabbatical leave and is pursuing advanced studies in agricultural engineering at Michigan State College.

Jan van Schilfgaarde, until recently employed as instructor in agricultural engineering at Iowa State College, recently accepted employment as research assistant professor of agricultural engineering at the University of North Carolina, Raleigh.

Warren R. Church, until recently a special graduate research assistant in agricultural engineering at Michigan State College, is now employed by the McDonald Cooperative Dairy Co., Flint, Mich.

Harry F. Blaney, research project supervisor, western soil and water management section, Soil and Water Conservation Research Branch (ARS), U.S. Department of Agriculture, and stationed at Los Angeles, is in attendance at the Tenth General Assembly of the International Union of Geodesy and Geophysics, being held in Rome, September 13-24.

Charles W. Wilson, who has been serving as assistant chief of the motor vehicle research division of Stevens Institute of Technology, is now employed by Wilson, Nuttall and Raimond, Engineers, Inc., Chestertown, Md.

Robert E. Stewart, professor of agricultural engineering, University of Missouri, together with Samuel Brody, professor of dairy husbandry, has accepted an invitation from the Australian Government to act as advisor on an animal climatic laboratory, similar to that which these two men operate at the University of Missouri, which is being set up by the Commonwealth Scientific and Industrial Research Organization of Australia.

John E. Dickson who has been employed as assistant agricultural engineer in the agricultural experiment station, Colorado A. & M. College, recently accepted employment as instructor in agricultural engineering at the University of Idaho, Moscow.

Robert B. Hurley, who has been on duty with the armed services, is now employed as work unit engineer by the Soil Conservation Service, U.S. Department of Agriculture, at Hondo, Tex.

Irving J. Pflug, who has been serving as an associate professor on the agricultural engineering staff of Massachusetts Agricultural Experiment Station, is temporarily employed in the agricultural engineering department of Michigan State College, where he is working for an advance degree in agricultural engineering.

Clark Prudhon reports that his company, Pruden Products Co., specialists in farm building equipment, has moved its factory and offices from Fort Atkinson to Evansville, Wis.

John M. Ross has resigned as assistant field superintendent for the Hawaiian Canneries Co., Ltd.., at Kapaa, Kauai, T. H., and has accepted a position in the product planning and programming section, Tractor and Implement Division, Ford Motor Co., at Birmingham, Mich. His new address is 505 S. Main St., Clawson, Mich.

Arnold R. Daum, formerly public relations specialist, American Petroleum Institute, has undertaken an assignment as associate director of a petroleum history project at Northwestern University, and as co-author of a two-volume history of the petroleum industry to be published in 1959, the oil industry's centennial year. He is located at the Center for Social Research, 629 Noyes St., Evanston, Ill.

Chester F. Culp recently resigned as chief engineer of Aerovent Fan Co., to accept the position of chief engineer in charge of the air-handling research laboratory of The Lennox Furnace Co., Marshalltown, Iowa.

Saint Elmo Dowling recently resigned as manager of the Alexander P. Thomas Farms at Cocoa, Fla., to accept the position of agricultural engineer in the agricultural engineering division of the Moore Dry Kiln Co., 1220 W. State St., Jacksonville, Fla.

Harold W. George is now employed as laboratory technician in tractor engineering at the West Allis Works of the Allis-Chalmers Mfg. Co., Tractor Division, Milwaukee, Wis.

Truman E. Hienton, head, farm electrification section, agricultural engineering research branch (ARS), U.S. Department of Agriculture, was recently elected to membership on the Scientific Manpower Commission as one of the two representatives of the Policy Committee for professional agricultural societies. While the organization of the Policy Committee has not been completed, it is expected that it will include representatives of the Soil Conservation Society of America, American Society of Range Management, American Society of Animal Production, American Dairy Science Association, American Society of Agronomy, and ASAE.

Grover C. Neff retired August 1 as president of the Wisconsin Power and Light Co. He had held that position since 1933, following service as vice-president since 1924, when the company was organized, and previous employment with predecessor companies. In all, he has served the company and its predecessors for 46 years. He is to continue as a member of the board of directors and will serve as its chairman.

Grover C. Neff

Mr. Neff is one of the nationally recognized early pioneers of rural electrification who contributed a great deal to the sound progress in that field which began in the early 1920's.

A native of Milford, Indiana, he graduated in civil engineering at Purdue University in 1907, and was awarded a professional C.E. degree in 1911. Following his graduation he worked as draftsman for the American Bridge Co. at Chicago for several months; joined the engineering firm of Meade and Seastone as resident engineer on steel tower transmission line construction; moved on in 1909 to become superintendent of the Southern Wisconsin Power Co., and in 1911 was named general superintendent of the Wisconsin River and Southern Wisconsin Power Companies. Four additional power companies were placed under his operating supervision in 1918 and in 1923 he was named general manager of the six organizations, which were reorganized in 1924 to form the Wisconsin Power and Light Company.

Supporting his belief in the opportunities for effective use of electric power on farms, he was one of the organizers and for many years chairman of the national Committee on the Relation of Electricity to Agriculture, the first organized, cooperative national effort to develop farm use of electric power. He became a member of ASAE in 1923 and was instrumental in the organization of its Rural Electric Division. In 1946-47 he served a term as president of the Edison Electric Institute. In 1951 he was honored with a Distinguished Service Citation from the University of Wisconsin, and in 1952 with an honorary doctor's degree from his alma mater, Purdue University.

Herbert J. Hurme, who has been employed as a graduate student in the agricultural engineering department at the University of Maine, is now located at the agricultural engineering department at Cornell University, Ithaca, N. Y., where he is working for a Ph.D. degree under a research assistantship program.

(Continued on page 668)

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NEWS OF ASAE MEMBERS

(Continued from page 666)

Earle F. Cox, who is employed as consultant in engineering and manufacturing by the engineering firm, Booz, Allen and Hamilton, 380 Madison Ave., New York, N. Y., and who has been serving the firm in Italy for some time, has recently been transferred to the New York office.

Alan M. Lehman reports that his tour of duty with the armed services has been terminated and that he has accepted employment at the research proving ground of the Caterpillar Tractor Co., Peoria, Ill.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Bly, Douglass A.—Water facilities engineer, Farmers Home Administration (Mail) 225 E. 2nd St., Edmond, Okla.

Burch, Billy G.—Engineer trainee, J. I. Case Co., Anniston, Ala. (Mail) 729 Wilmer Ave.

Galt, Harry L.—Agricultural engineer, Near East Foundation, New York City, N. Y. (Mail) USOM-Iran, APO 205, %Postmaster

Garner, Thomas H.—Research fellow in peanut mechanization, North Carolina State College, Raleigh, N. C. (Mail) 2714 Vanderbilt Ave.

Garver, Charles M.—U.S. Army (Mail) RR 1, Box 275, Visalia, Calif.

Gillespie, Lowry H. Jr.—Division rural engineer, Georgia Power Co., Macon, Ga.

Goff, Julian P.—U.S. Army, Signal Corps (Mail) RR 2, Rocky Mount, N. C.

Johnson, William H.—Graduate student in agricultural engineering, North Carolina State College (Mail) RR 3, Box 357, Fayetteville, N. C.

Kelly, James F.—Vice-president and general manager, Aeroglide Corp., Raleigh, N. C. (Mail) 833 Woodburn Rd.

Kohlhund, Franklin S.—Office engineer, The Lutcher and Moore Lumber Co., Orange, Tex. (Mail) 19 8th St.

Norum, Edward M. Jr.—Associate agricultural engineer, Experiment Station, HSPA, 1527 Keeaumoka St., Honolulu 14, Hawaii

Potter, Harry E.—Student, University of Maine (Mail) RR 1, Waterville, Me.

Russell, Richard R.—Product test engineer, International Harvester Co. (Mail) Bristol, Vt.

Spelts, Richard E. Jr.—General manager, Spelts of Nebraska, Inc., 612 E. Fourth St., Grand Island, Nebr.

Walte, Charles Jr.—Director of Farm Institute Reynolds Metals Co., 2000 S. Ninth St., Louisville, Ky.

Wendland, Darwin E.—Junior engineer, Minneapolis-Moline Implement Co., Hopkins, Minn. (Mail) 117 8th Ave., So.

Wiseman, Calvin M.—Specifications writer, Louisville District Office, Army Corps of Engineers (Mail) 522 W. Harrison Ave., Clarksville, Ind.

Transfer of Membership Grade

Cocke, Joseph B.—Assistant agricultural engineer (BPISAE), USDA, Belle Glade, Fla. (Mail) Box 763 (Affiliate to Associate Member)

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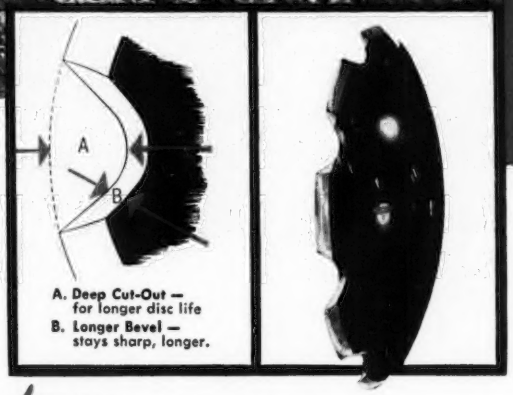

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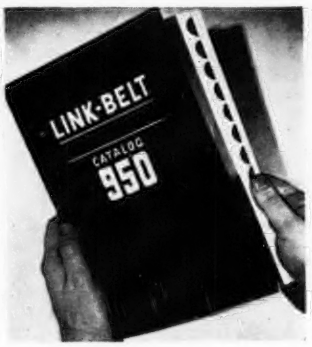
Young Radiator Co., Racine, Wis., announces its new "Monofin" plate-type fin and round-tube core which is designed for engine-cooling units and other heat-transfer applications. This new core is made up of 7 fins per inch and provides 58 percent more extended surface and seven times more heat-transfer surface than is provided with circular-fin cores with edge contact. This new core cuts maintenance and replacement costs. Tubes sheathed with "Monofins" are removed when damaged, thereby maintaining full heat-transfer efficiency of the entire core area. Straight-in-line fin arrangement permits maximum air flow for high-efficiency cooling with minimum pressure drop with resultant savings in horsepower and greater fin cleanliness. The new "Monofin" has a positive mechanical bond with fin-collar to fin-collar contact along the entire length of the tube, adding to "bursting strength" and protecting it from injurious impingement and atmospheric corrosion. The cores can be used with any tubing material without brass or solder problems and are available in copper, brass, admiralty, aluminum or steel tubes, and copper or aluminum fins for every type of service.

Industrial Engine Brochure

Willys Motors, Inc., Industrial Engine Dept., 940 N. Cove Blvd., Toledo 1, Ohio, will send on request to interested readers a copy of a brochure describing its line of 4-cylinder industrial engines – model L-4 "Jeep" and model F-4 "Hurricane." Complete engine details are given both for the L and F-head designs including power, torque and fuel curves at various speeds. The brochure also includes special features, installation diagrams, and other general descriptive material.

Chain and Sprocket Catalog

Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., will send on request to interested readers a copy of its new 340-page standard products Catalog 950 just issued. The Company's products shown in this catalog fall into several major classifications, including chains and sprockets for conveying, elevating and power transmission. Tables of preengineered drives facilitate the selection of standard roller chain drives and silent chain drives. Complete listings are given of stock and made-to-order chains and sprockets. The line of enclosed gear drives includes the newly developed parallel shaft helical drives in addition to herringbone, worm, and electrofluid drives. The PIV variable-speed drive grouping includes 20-25 hp H6 units with input and output gears.

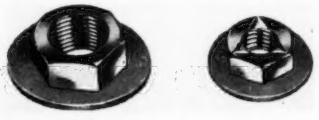


Transmission products include ball and roller bearings and incorporate listings of the new JPS light-duty ball bearings and the LPK mill-type roller bearings for the heaviest applications. The broad range of other products for efficient power transmission includes babbitted bearings, pulleys, gears, clutches and couplings.

The catalog has a flexible cover and thumb index, and clear and concise capacity charts and dimension tables will aid in the rapid selection of standard products and stock items for new installations.

New Flange Nut

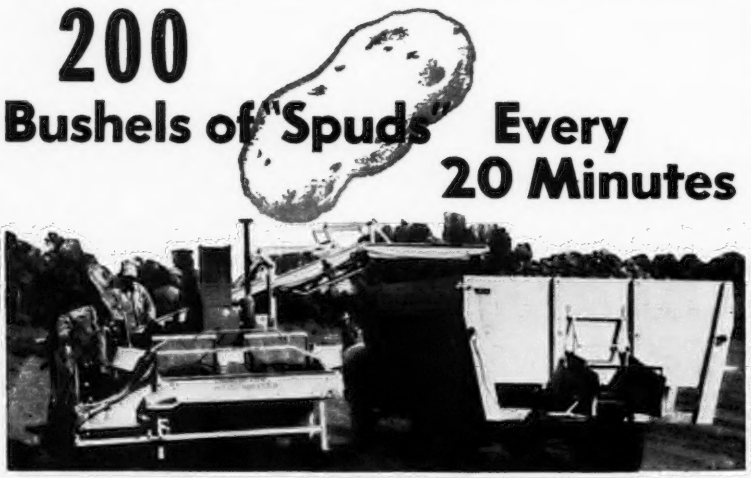
Grip Nut Co., 310 S. Michigan Ave., Chicago 4, Ill., announces that it is now manufacturing Gripco flange nuts in sizes ¼ through ⅝ with either National Fine or



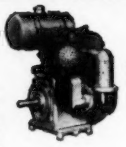
National Coarse threads. Gripco flange nuts are now available with or without the self-locking feature. This one-piece combination nut and washer is used as a compressor and motor hold-down nut as well as for many other applications.

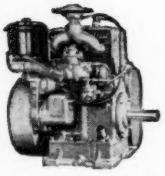
(Continued on page 672)

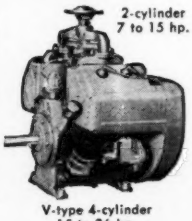
200 Bushels of "Spuds" Every 20 Minutes



with WISCONSIN-Powered Potato Harvester


4-cycle single cyl. 3 to 9 hp.




2-cylinder 7 to 15 hp.

V-type 4-cylinder 15 to 36 hp.

This harvester digs 2 rows of potatoes at once . . . working steadily day in and day out. It's built by Champion Corporation, Hammond, Indiana, and powered by a Wisconsin Heavy-Duty Air-Cooled Engine.

A Champion user in North Dakota tells how well the unit performs. He writes, "We harvested 235 acres in 170 hours operating time which averaged 243 bushels per acre. In figuring our .092¢ per bushel costs, we included our labor bill, fuel used, trucking and depreciation on the equipment as well as repairs purchased for the harvester. The average figure for hand picking in this vicinity in 1952 was 10¢ per bushel and the loading and hauling would be in addition. Our potatoes have practically no mechanical injury. We took out our entire crop with only two people on the harvester in addition to the operator. We're more than satisfied."

This story is typical of fine equipment service and something else as well. It illustrates, too, the dependability of Wisconsin Engines, matching the performance of the equipment they power.

Write for details about all models . . . 4-cycle single-cylinder, 2-cylinder and V-type 4-cylinder types, 3 to 36 hp.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

A 8034-½-I

Ask for G-E Motors and Control on all Electrified Farm Equipment you buy!

GENERAL ELECTRIC

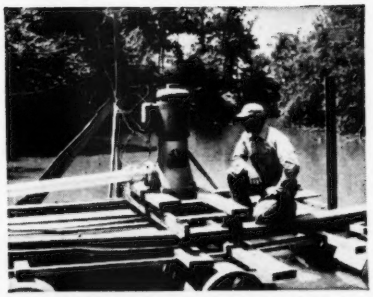
FarmNews

Ask for G-E Motors and Control on all Electrified Farm Equipment you buy!

MORE POWER TO THE AMERICAN FARMER through more electricity on the farm

NOW FARMER CAN HARVEST 3 WEEKS SOONER

Newly designed storage building and drying equipment cut field loss by making earlier harvesting possible



SMOOTH RUNNING pump is inspected by Mr. Tucker. Pump can deliver 160 gpm.

CROP YIELD DOUBLED BY LOW-COST IRRIGATION

Located in the "medium" soil area of Kentucky, Mr. Samuel Tucker's small farm near Owensboro grows a wide assortment of cash crops, particularly corn and tobacco. In 1953 Mr. Tucker bought this economical irrigation system, on a time payment basis, to irrigate 33 acres. A nearby creek was dammed up and the 160 gpm turbine pump was mounted on a raft in the middle of the reservoir connecting to his portable irrigation system. The result is a virtually doubled crop yield from his irrigated land.

Mr. Tucker turns on the system in the morning before he goes out in the fields. In 4½ hours an automatic timer turns the water off. He repeats the operation in the afternoon and again in the evening, moving the lines each time to irrigate an area of 1.1 acres. Thus 3.3 acres are irrigated per day, or 33 acres in 10 days with a minimum of interference with Mr. Tucker's work schedule.

The system, with the pump powered by a dependable G-E Tri-Clad* motor, is simple and efficient. As Mr. Tucker says, "This system is economical to operate and so simple to start and stop that my 9 year old son does this job while I am moving lines. I wouldn't trade it for any other type of outfit."

For full details, check coupon below.

WEATHER-TIGHT building keeps corn crop safer and clean at low storage cost per bushel.

EVEN DISTRIBUTION of natural, unheated air is provided by this forced air system.

"Last year, before my new crop storage building and drying equipment were installed, I didn't harvest my corn till late in September," says Albert Brauer of Stonington, Ill. "By that time it was down to about 13% moisture content and my field loss was high.

"But now, with my new drying equipment, I can harvest two or three weeks earlier—at 22 to 24 percent moisture—and reduce field loss. Then by storing in my new building, I can bring the moisture down to a safer level with my drying equipment.

"I'm sure of getting the support price—and maybe holding for an even higher market price—now that I can store in my 6,800-bushel crop storage building. What's more, it's weather-tight and rodent-proof. This keeps my crops clean for better feed and higher market prices when I sell."

For fast, even drying, Mr. Brauer's building is equipped with a drying tunnel and a pressure fan powered by a dependable G-E Tri-Clad* 3-hp motor. For details check "Storage equipment" below.

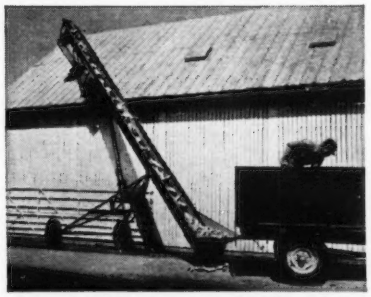
*Registered Trademark of General Electric Co.

First lightweight elevator able to handle bales, ear corn, grain saves Ohio farmer time and labor

One of the latest developments in farm equipment is this new, lightweight aluminum elevator designed to handle bales. A top performer in moving small grain and ear corn, it can be ready in seconds for bales. Its low cost and "workhorse" performance make it ideal on both large and small farms.

Here's what Mr. Vance C. Hendricks, of Franklin County, Ohio, has to say about his new, multi-purpose elevator: "The first one I picked up was in 1947. It's done a fine job, but it's nothing like the new model out this year."

"Everybody should agree", says Hendricks, "that I got my money out of that old one. I know it's saved me hundreds of hours in six years, and a lot of hard work. For my money, this new elevator is the best buy a farmer can make if he wants something that will help move grain. I use it for filling my cribs and bins and loading out into a truck."



FAST DELIVERY of ear corn, ensilage, bales, etc. is easy with new elevator.

Engineered for economy and powered for performance by a rugged G-E motor, this amazing newcomer to the field makes many hard jobs easy. For more information check "elevator" on coupon at right.

GENERAL ELECTRIC COMPANY
Section 330-2D, Schenectady 5, N. Y.

I would like additional information on the following equipment.

- ☐ Storage Equipment
- ☐ Irrigation System
- ☐ Multi-purpose Elevator
- ☐ How to Choose Your Motor

NAME_____

ADDRESS_____

CITY_____ STATE_____

New Products and Catalogs

(Continued from page 670)

Rotary Cutter

John Deere, Moline, Ill., announces its new Gyramor rotary cutter which cuts, shreds, and spreads corn and cotton stalks, saplings, brush, sagebrush, mesquite, palmetto, Johnson grass, cover crops, pasture weeds — also trims pastures and chops and spreads orchard and vineyard trimmings. The cutter works with the John Deere 40 series and other standard 3-point-hitch tractors.

The cutter consists of a rugged rotor equipped with tough, flail-type blades which revolve at a high speed within a steel housing, powered by the tractor power take-off through a drive shaft and enclosed mitred

gears. Three types of reversible blades are available. A shredding attachment, consisting of two stationary knives and a rotor section to accommodate two blades on each end of the rotor, is available as extra equipment. A grille at the rear of the rotor housing can be set at different openings to accomplish more or less shredding.

Safe Lube Oil Filtering

Caterpillar Tractor Co., Peoria, Ill., will send on request to interested readers a new booklet entitled "No Short Cuts to Safe Filtering" (Form No. 31085) which points out the necessity of efficient, dependable filtering of lubricating oil. This 8-page booklet discusses the risks in short-cuts in lubricating oil filter systems and the importance of using the right filter. A step-by-step discussion of what a filter must accomplish and a description of how a full-flow filtering system serves the engine are also included in this publication.

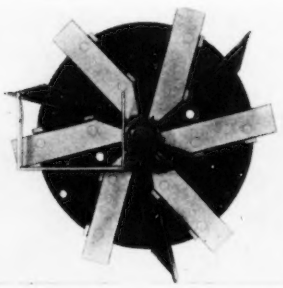
Roller Chain-Sprocket Catalog

Diamond Chain Co., Indianapolis 7, Ind., will send on request to interested readers a copy of its new catalog 754, covering its complete line of stock roller chains and

sprockets. Stocked by distributors in every industrial area, the line includes minimum-bore sprockets for reboring as well as finished bore and taper-lock bushed sprockets which are ready to use. Chain selection and application data is included in the catalog.

Field Forage Harvester

New Holland Machine Co., New Holland, Pa., announces a new field forage harvester equipped with a six-knife flywheel as standard equipment which permits the operator to use 1, 2, 3, 4, or 6 knives to secure lengths of cut from ¼ inch to 8½

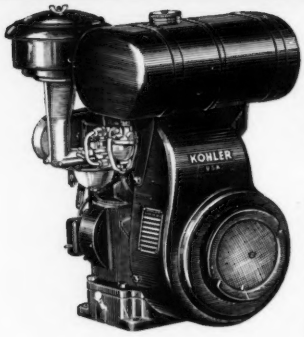


inches, thus making the machine suitable for all crops. The new harvester base unit (engine model) operates with a new engine gear reduction unit that simplifies power transfer. A jack shaft is used for transmitting power from the base unit to the sickle drive on the corn and sickle-bar attachments. By use of the jack shaft more positive drive to the sickle is achieved, resulting in cleaner cutting through more constant power.

(Continued on page 674)

KOHLER ENGINES

4-CYCLE
AIR-COOLED



K90 3.6 H.P.
K160 6.6 H.P.
K330 11.8 H.P.
K660 26.8 H.P.

Kohler Engines are engineered and manufactured to the high standards which have made the Kohler mark known for quality the world over.

Power for garden tractors, pumps, sprayers, snow removal equipment, grain elevators, hoists, portable saws, concrete mixers, compressors, industrial lift trucks.

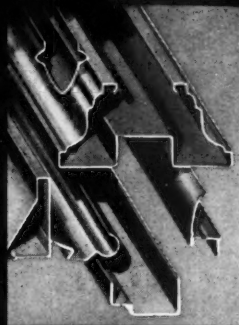
Write for information

Kohler Co., Kohler, Wisconsin
Established 1873

KOHLER OF KOHLER

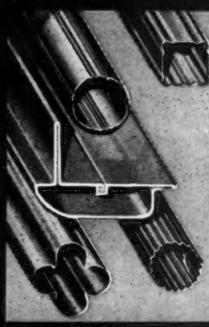
PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
AIR-COOLED ENGINES • PRECISION CONTROLS

METAL SHAPES: MOULDINGS



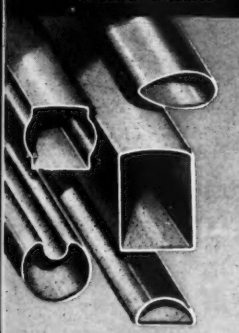
ANGLES & CHANNELS

LOCK SEAM TUBING



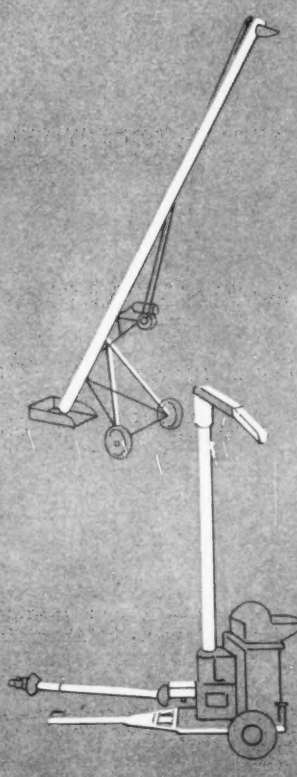
TIGHT & OPEN SEAM

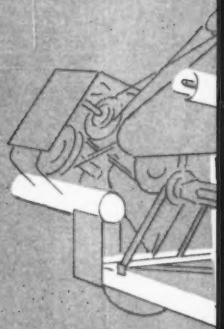
WELDED TUBING



Van Huffel cold formed metal shapes and tubing simplify design and cut production costs for the makers of

farm equipment





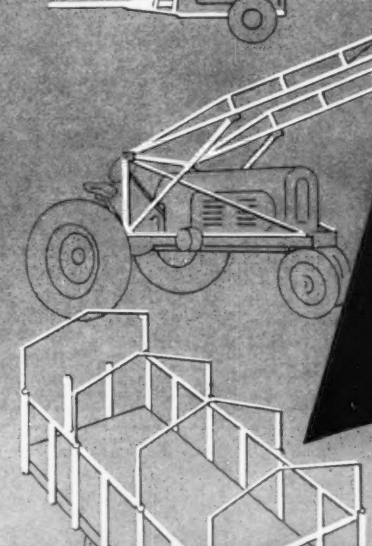
No matter what you make that farmers use, chances are Van Huffel Cold Formed Metal Shapes and Tubing can help you make it faster, cheaper and better.

Faster **because cold formed parts require very little or no machining; parts come to you shaped, cut, punched, or bent to your specifications.**

Cheaper **because of the high strength-to-weight ratio you can, in many cases, use lighter gauges, or smaller sizes in place of solid metals. Parts are uniform in thickness, free from scale, and ready to paint.**

Better **because of the wider latitude in choice of materials, design possibilities and fabrication methods. Shapes and tubing can be produced in Cold Rolled, Hot Rolled and High Tensile Steels. Van Huffel cold forms strip metals 1/2" to 33" wide; regular and irregular shapes in .018 to .312 gauge; tubing from 3/16" to 6" in diameter in any lengths.**

Write today for free portfolio of cost reducing ideas that have taken shape in the farm equipment field



Van Huffel

TUBE CORPORATION · WARREN, OHIO

Where ideas take shape for makers of farm equipment

Corrections

("Hot Weather Shelters for Livestock," pages 638, 639, 642)

THE attention of readers is called to the following corrections in the article entitled "Hot Weather Shelters for Livestock," by G. L. Nelson *et al*, beginning on page 638 of this issue:

In the formula in the first column on page 638, the symbols "OC_D" and "OC_d" should be "α_D" and "α_d" instead. This applies also to the formulas at the bottom of the second column on page 638 and to near the top of the first column on page 639.

In the two formulas at the bottom of the second column on page 638, the symbols "ϵ_1" and "R_1" should be "ϵ_L" and "R_L".

The fifth line of the second paragraph in the second column on page 639 should read: "the cube to receive panels, each constructed as a sandwich . . ."

The first line of the second paragraph beginning on page 642 should read: "Values of b/f_{cro} for metal roofing surfaces were obtained in . . ."

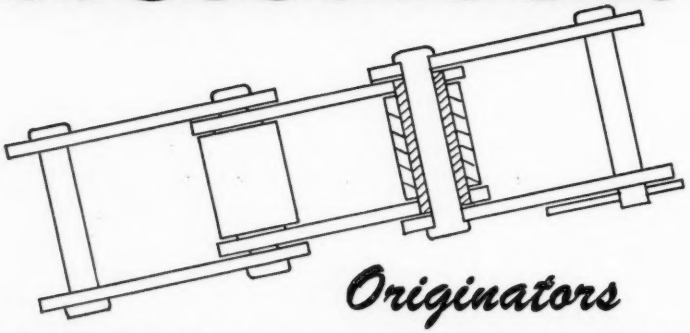
New Products and Catalogs

(Continued from page 672)

Ductile Iron Bulletin

The International Nickel Co., 67 Wall St., New York 5, N. Y., will send on request to interested readers a copy of its bulletin DI-1, "Ductile Cast Iron — A New Engineering Material," which describes a recently developed family of irons which possesses the process advantages of cast iron and which has engineering properties that approach those of cast steel. Strengths up to 120,000 psi, substantial ductility and resistance to heat and wear are reported. Potential applications in numerous fields are indicated.

REDUCE COSTLY BREAKDOWNS WITH CHAINS, INC.



Originators

OF HIGH QUALITY LOW COST IMPLEMENT ROLLER CHAIN

Chains, Incorporated is supplying complete quality chain drives for combines, corn pickers, spreaders and other applications in the agricultural field as well as the industrial field. For the best in roller chain at attractive prices

WRITE FOR COMPLETE DETAILS

CHAINS, INC.

13943 PARK AVENUE DOLTON, ILLINOIS

A-E in USDA Reorganization

(Continued from page 664)

OUTLINE II. AGRICULTURAL RESEARCH SERVICE — ADMINISTRATION

A Research—Deputy Administrator

I Crops Research—Director

1 Field Crops Research Branch—Chief

2 Horticultural Crops Research Branch —Chief

3 Entomology Research Branch—Chief

II Farm and Land Management Research—Director

4 *Soil and Water Conservation Research Branch*—Chief

5 *Agricultural Engineering Research Branch*—Chief

6 Production Economics Research Branch —Chief

III Livestock Research—Director

7 Animal Disease and Parasite Research Branch—Chief

8 Dairy Husbandry Research Branch — Chief

9 Animal and Poultry Husbandry Research Branch—Chief

IV Human Nutrition and Home Economics Research—Director

10 Human Nutrition Research Branch—Chief

11 Home Economics Research Branch—Chief

V Utilization Research—Director

12 Northern Utilization Research Branch —Chief

13 Southern Utilization Research Branch —Chief

14 Eastern Utilization Research Branch —Chief

15 Western Utilization Research Branch —Chief

16 Washington Utilization Research Branch—Chief

B Regulatory Programs—Deputy Administrator

I Crops Regulatory Programs—Director

1 Plant Pest Control Branch—Chief

2 Plant Quarantine Branch—Chief

II Livestock Regulatory Programs—Director

3 Animal Disease Eradication Branch—Chief

4 Animal Quarantine Branch—Chief

5 Meat Inspection Branch—Chief

C Office of Experiment Stations—Assistant Administrator

I State Experiment Stations Division—Director

II Territorial Experiment Stations Division —Director

OUTLINE III. FARM AND LAND MANAGEMENT RESEARCH—DIRECTOR

I Soil and Water Conservation Research Branch—Chief

1 Soil-Plant Relationship Section—Head

2 Fertilizer and Agricultural Lime Section—Head

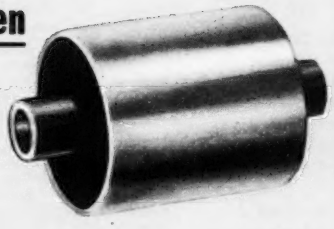
3 *Eastern Soil and Water Management Section*—Head

4 *Western Soil and Water Management Section*—Head

5 *Watershed Hydrology Section*—Head

(Continued on page 676)

Farm-Proven Silentbloc Bearings



Never Require Lubrication!

These unique rubber-in-metal bearings correct misalignment, reduce noise, cushion shock, and handle oscillating motion *without lubrication of any kind.* In addition, they eliminate metal-to-metal wear and provide long trouble-free operation.

General Silentbloc bearings and bushings are used on agricultural machinery wherever motion is a problem. Special Silentbloc units can also be designed and manufactured to meet your particular need. Our service also covers extruded plastics and rubber, molded rubber and fiberglas, metal stampings, rubber-to-metal. Write for the full story today.

"From Plans to Products in Plastics and Rubber"

THE GENERAL TIRE *Industrial Products Division*
WABASH INDIANA

The General Tire & Rubber Company
Industrial Products Division
Wabash, Indiana

☐ Send booklet on Silentbloc products (4240)
☐ Send booklet on complete products and services (4252)
☐ Have your representative contact us.

Company_____ Name_____

City_____ Street_____ State_____

AE-9-54

DEPENDABLE PERFORMANCE calls for STOW

Picture courtesy BROOME G. L. F. ELEVATOR

G.L.F. depends on STOW flexible shafting for speedy grain delivery!

"Since installing STOW flexible shafting on our bulk feed delivery units, we have lost no time due to breakdowns and have had no maintenance problems in over five months of continuous service", says Mr. Joseph Collins, manager, Broome G.L.F. Elevator.

This STOW flexible shaft application replaces a universal joint series which would not stand up under the rugged conditions to which it was subject during deliveries to farms. Primary cause of the failure, according to Mr. Collins, was the steep angles through which the universal joints had to operate. Prior to the installation of STOW flexible shafting, Broome G.L.F.'s grain delivery units suffered frequent breakdowns, each of which involved three or four-hour delays and upped delivery costs.

This is another excellent example proving the efficiency, the practicability of STOW flexible shafting. Why not consult with STOW engineers on *your* next power transmission problem?

WRITE TODAY for your FREE Torque Calculator and Bulletin 525 containing complete data on STOW flexible shafting. No obligation, of course.

STOW — first in flexible shafting since 1875

39 SHEAR STREET
BINGHAMTON, NEW YORK

A-E in USDA Reorganization

(Continued from page 674)

II Agricultural Engineering Research Branch—Chief
- 6 *Farm Buildings Section*—Head
- 7 *Farm Machinery Section*—Head
- 8 *Tillage Machinery Laboratory Section*—Head
- 9 *Farm Electrification Section*—Head
- 10 *Mechanical Preparation and Conditioning Section*—Head

III Production Economics Research Branch—Chief
- 11 Farming Efficiency Section—Head
- 12 Production Income and Costs Section Head
- 13 Agricultural Finance Section—Head
- 14 Land and Water Section—Head
- 15 Field Research Section—Head

OUTLINE IV. AGRICULTURAL MARKETING SERVICE—ADMINISTRATOR

I Marketing Research and Statistics—Deputy Administrator
- 1 Agricultural Economics Division—Director
- 2 Agricultural Estimates Division—Director
- 3 *Marketing Research Division*—Director

II Marketing Services—Deputy Administrator
- 4 Cotton Division—Director
- 5 Dairy Division—Director
- 6 Farm Distribution Division—Director
- 7 Fruit and Vegetable Division—Director
- 8 Grain Division—Director
- 9 Livestock Division—Director
- 10 Poultry Division—Director
- 11 Tobacco Division—Director
- 12 U.S. Warehouse Act Branch—Chief
- 13 Freight Rate Service Branch—Chief

OUTLINE V. MARKETING RESEARCH DIVISION—DIRECTOR

I Market Development Branch—Chief
- 1 Market Surveys Section—Head
- 2 Product Development Section—Head
- 3 Merchandising Methods Section—Head
- 4 Distribution Programs Research Section—Head

II Biological Sciences Branch—Chief
- 5 *Quality Maintenance and Improvement Section*—Head
- 6 *Quality Evaluation Section*—Head
- 7 *Stored-Product Insects Section*—Head

III Transportation and Facilities Branch—Chief
- 8 Marketing Facilities Planning Section—Head
- 9 *Wholesaling and Retailing Section*—Head
- 10 *Transportation Section*—Head
- 11 *Handling and Facilities Research Section*

IV Market Organization and Costs Branch—Chief
- 12 Dairy Section—Head
- 13 Livestock Section—Head
- 14 Poultry Section—Head
- 15 Grains and Feeds Section—Head
- 16 Fruit and Vegetables Section—Head
- 17 Fibers Section—Head
- 18 Special Crops Section—Head
- 19 Market Structure and Practices Section—Head
- 20 Market Information and Statistics Section—Head

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—APRIL—O-90-613, 98-614, 106-615. MAY—O-155-623, 108-624, 162-625, 173-626. JUNE—O-180-627, 181-628, 197-629, 198-630, 182-631. JULY—O-204-633, 205-634, 207-635, 209-636, 208-637, 219-638, 222-639, 223-640, 214-641, 231-642, 232-643. AUGUST—O-242-644, 248-645, 249-646, 250-647, 251-648, 244-649.

POSITIONS WANTED—APRIL—W-93-123, 125-126, 107-127. MAY—W122-128, 146-129, 128-130. JUNE—W-115-131, 164-133, 169-134, 141-135, 179-136, 199-137. JULY—W-177-138, 189-139, 224-141. AUGUST—W-237-142, 252-143, 265-144.

NEW POSITIONS OPEN

PRODUCT DESIGN ENGINEERS (2) and JUNIOR PRODUCT DESIGN ENGINEERS (2) for work on harvesting equipment with leading full line farm machinery manufacturer in Midwest. BS deg in agricultural or mechanical engineering. Design engineers should have 2 to 10 yr experience on either combines, corn pickers, or forage harvesters, and be capable of assuming design responsibility, including following a project through development, field test, and preparation of specifications for production release. For juniors, prefer recent graduates interested in product design on combines, corn pickers, balers, or forage harvesters. Must be aggressive, with initiative to train for responsible design engineer positions. Salary open. O-276-650

AGRICULTURAL ENGINEER for research in a southern agricultural experiment station. Age 30 to 45. Advanced degree in agricultural engineering and experience sufficient for a professor rating. Must be able to work with others. Good opportunity for advancement. Salary $7000-7500. O-262-651

(Continued on page 678)

New "Monarch"

BY MILSCO *America's Leading Seat Specialists*

FOR MANUFACTURERS OF MOBILE EQUIPMENT

No. 344 *With Or Without Fore And Aft Attachment*

★4 Point Body Comfort

The new Milsco "Monarch" features deep cushion comfort with full 4-point body support. Ruggedly built; attractively styled. Designed for stepped-up work efficiency on many types of mobile equipment. (Sold to equipment manufacturers only.) Write for catalog on your company letterhead.

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LAMINATED PLYWOOD BACK AND SEAT

GENUINE OR ARTIFICIAL LEATHER

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FOR EVERY CROP

FOR EVERY NEED

PRE-EMERGENCE SPRAYING
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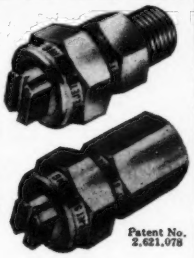
THERE'S A TeeJet® TO DO THE JOB
SPRAY NOZZLE



Over 400 interchangeable orifice tips to fit any TeeJet Spray Nozzle . . . give you a choice to meet the need of any crop and any type of spraying. Tip types include flat spray, hollow cone, full cone, and straight stream. Try TeeJet Spray Nozzles . . . proved best in the field . . . guaranteed for exact performance.

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RELATED EQUIPMENT . . . . wide range of related equipment such as BoomJet for single nozzle broadcast spraying in patterns up to 66 feet wide . . . GunJet spray guns for spraying trees, cattle, and scrub growth . . . and strainers, connectors and fittings.

For Complete Information . . . write for Bulletin 58

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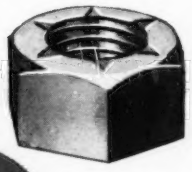
for easier
FASTER LOCKING
of threaded fasteners at lower cost!



The Gripco Lock Nut one-piece design gives a tighter more positive holding action for faster application at less cost. And for 50 years the Gripco locking feature has proven itself by an ever increasing use. All-one-piece to cut initial cost—(no inserts, outside devices or complicated features)—the extreme holding or locking action is produced by a simple, vertical thread deflection. For stress, wear or vibration, a Gripco Lock Nut will hold tighter, wear longer. Impervious to oil or water. Write for samples and full details.

GRIPCO PRODUCTS INCLUDE:
Gripco Lock Nuts, New Gripco "Clinch" Nuts, Gripco Hi-Nuts, Gripco Pilot-Projection and Countersunk Weld Nuts with or without Gripco locking feature.

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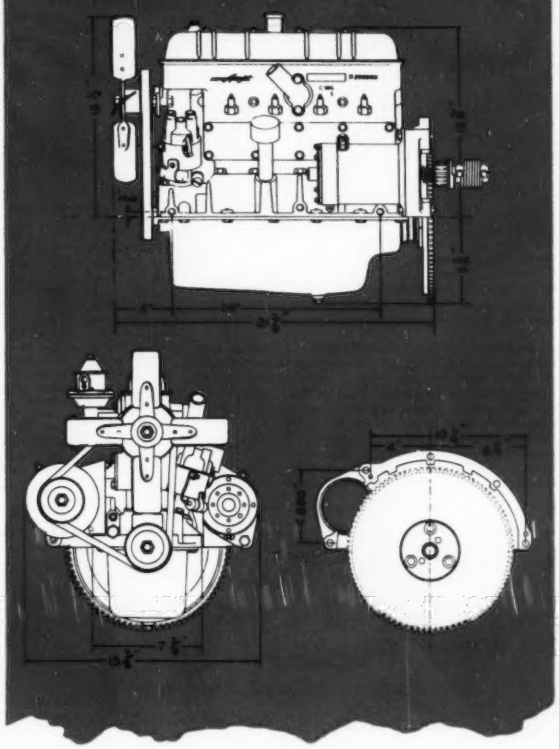
GRIP NUT COMPANY
"after 50 years still holding strong"
311-M SOUTH MICHIGAN AVENUE, CHICAGO 4, ILLINOIS

THE MOST ECONOMICAL, DEPENDABLE 25½ H. P. ENGINE EVER PUT ON A PIECE OF FARM OR INDUSTRIAL EQUIPMENT



A favorite of the Armed Services. Regularly passes 1,000 hour continuous running tests. Weighs only 101.1 lbs. Uses less than 1½ gals. of gas per hour under full throttle. 7.1 compression ratio. A magnificently designed, precision made engine that will increase the value and reputation of your equipment. Write today for the facts.

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INDUSTRIAL	FARM EQUIPMENT
Cement mixer	Forage harvester
Generator set	Dump wagon hoist
Ditching machine	Irrigation pumps
Diaphragm pump	Deep well pump
Post hole digger	Hydraulic unit
Paving breaker	Sprinkler pumps
Portable carpentry shops, etc.	Garden tractor
	Well drilling

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AEROJET-GENERAL CORPORATION
2530 SPRING GROVE AVENUE • CINCINNATI 14, OHIO
A subsidiary of The General Tire & Rubber Company

Personnel Service Bulletin

(Continued from page 676)

AGRICULTURAL ENGINEER for research assistant and instructor in soil and water field, in a western land grant college. BS deg in agricultural engineering, with good scholastic record. Specialization in soil and water, and farm background, desirable. Good health, initiative, dependability, and resourcefulness. New position established for two years, may be made permanent. Limited graduate work may be taken. One month vacation. Opening effective September 15. Salary open, approx. $4000-4400. O-286-652

AGRICULTURAL ENGINEER for design, development and test work on agricultural equipment, attachments, and specialties, with established manufacturer in Midwest. Age 25-35. BS deg in agricultural engineering, or equivalent. Farm background and 3 to 5 yr in design, development and test experience in farm implement field. Must have initiative, dependability, power of analysis, and good judgment, knowledge of engineering principles, and ability to work with people. Good opportunity for advancement to responsible administrative position. Salary open. O-288-653

AGRICULTURAL ENGINEER for graduate research assistant in a land grant college in the southeast. Work will be on concrete storages for liquid fertilizer solutions. Age 20 to 30. BS deg in agricultural engineering or equivalent. Usual personal qualifications, plus genuine interest in basic research. Appointment for one year, may be continued second year to complete requirements for MS deg in agricultural engineering. Salary $1800, half-time basis. O-293-654

AGRICULTURAL ENGINEER for sales engineering work with wholesale hardware jobber in Southeast. Some travel in comparatively small area, to acquaint retail dealers with lines of equipment, with emphasis on new building materials, new applications for established materials, water systems, irrigation layouts and equipment, piping, spray and dusting equipment. Prefer an engineer born and raised in Southeast, with pleasing personality, high level of initiative and imagination, an active interest in sales and sales promotion, and desire to get ahead in private business. Excellent opportunity with well-established business under new progressive management. Salary $4000 plus sales bonus arrangement. O-300-655

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for extension, research or sales and service work in structures, irrigation equipment, or soil and water field anywhere in USA or in Mexico or South America. Will travel. Married. Age 38. No disability. BS deg in agricultural engineering, (1950) Texas A & M College. Additional study in architectural and electrical engineering at American School, Chicago. Farm background. Gunsmith 2 yr. War enlisted service in Army Air Corps, in field of electronics, as link and celestial navigation trainer operator. Agricultural engineer with SCS 42 mo in sprinkler and flood irrigation design and layout and application of power equipment for erosion control work. Available on two weeks notice. Salary approximately $5000. W-283-145

AGRICULTURAL ENGINEER for design development or research in power and machinery or farm structures, with industry anywhere in USA. Married. Age 28. BS deg in agricultural engineering, Michigan State College. Experience 19 mo as trainee with farm equipment manufacturer. Enlisted service in USAAF, 2½ yr. Available on 3 weeks notice. Salary open. W-273-146.

AGRICULTURAL ENGINEER for educational, consulting, or sales work in soils, irrigation, and drainage field. Location: West Coast, Rocky Mountain States or South America preferred. Age 36. Married. Own home and automobile. BS deg in agriculture 1946. One quarter completed toward MS deg in irrigation and soils, 1952. Over 9 yr experience in the engineering field, including 3½ yr as extension agricultural engineer; 5 yr experience in conservation, soils and irrigation; 4 yr experience in engineering computations, estimating, surveying farm buildings etc. Registered professional engineer, State of N. M. Enlisted and commissioned service Army Ordnance, W.W.II. Willing to travel. Salary $5000 or better depending on other conditions of employment. W-246-147

AGRICULTURAL ENGINEER for farm management, extension, consulting or rural electrification utilization work. Married. Age 32. BS deg in agricultural engineering 1943. Service 3¼ yr as naval commissioned officer in electronics. One year assistant extension agricultural engineer; 9 mo sales and installation rural electrical products for large retail firm; 4 yr instructor in veteran on farm training program; 6 yr operating and managing grain and livestock farm in a northern state. Available in October or November. Salary open. W-260-148

AGRICULTURAL ENGINEER for design, development, research, teaching, sales, service, writing or management in rural electric, soil and water or product processing field, with industry or public service in West, Southwest, South or Southeast. Married. Age 33. No disability. BS deg, 1953 Louisiana Polytechnic Institute. Farm background. Agricultural engineering work since 1939 except for periods with Army Engineer Corps, Ordnance engineers, and private engineering firm. Available Sept. 15. Salary open. W-266-149

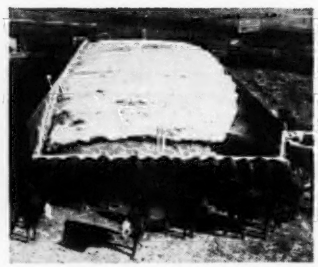
AGRICULTURAL ENGINEER with creative ability for design, development, or other position with manufacturer or sales organization in the Southeast. Married. Age 30. No disability. Air Force enlisted service. BS deg in agricultural engineering, power and machinery, 1949, N. C. State College. Farm background. Six months sales experience. One year research and development experience with land grant college in farm sprayer and cotton harvester design. Three and one-half years with manufacturer as development engineer, last one and one-half years as manager of research and development department. Three seasons of cotton harvester design and testing, four seasons of castor bean harvester design and testing, other projects also, some now being manufactured. Will send folder of photographs illustrating scope of experience. Desire to relocate because of family considerations. Available at end of present development project, about December 15. Desire salary and responsibilities equal to those of present position. W-294-150.

(Continued on page 680)

How to Build

Feed-Saving, Low Cost Silos with SISALKRAFT

Temporary Upright Silos — Sisalkraft is used to line the sides of wire or wood fencing. Can be built in ten easy steps. Write for instruction folder.



Stack or Box Silos — Feed stored on hard-surfaced floor with reenforced walls. Top completely covered with Sisalkraft in 5, 6 or 7 foot widths.

Tough, waterproof, airtight Sisalkraft protects feed from air, rain, and sundamage. Its steel-strong reenforcing makes it sturdy, hard to tear, long-lasting, low cost building material. Here are examples:

For Permanent Silos, Sisalkraft makes effective airtight seals for tops and for doors.

Other money-saving Sisalkraft uses: protecting machinery and equipment from rain, making buildings weathertight, membrane between fill and concrete slab, for covering new concrete.

Trench Silos — Sisalkraft covering the top holds surface spoilage to minimum.

SISALKRAFT PRODUCTS

AMERICAN SISALKRAFT CORPORATION

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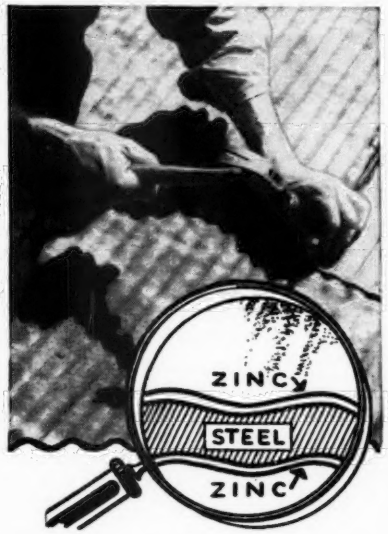
MORE FOR YOUR MONEY with *Grade-Marked* GALVANIZED ROOFING



Value in galvanized roofing is measured in rust-free service—and rust-free service depends on the weight or thickness of the zinc coating.

This weight or thickness of zinc coating cannot be determined by looking at a galvanized sheet.

Insist on *grade-marked* galvanized roofing and know what you are getting. A small difference in the weight of coating means a large difference in the length of service.

It is thrifty to purchase metal roofing that is *grade-marked* to show the weight of the zinc coating.

Select the proper grade for the proper use—and for long rust-free service life and lowest per-year cost . . .

Specify a heavy-coated sheet such as "Seal of Quality," the SUPER SHEET for SUPER SERVICE

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FREE . . . INSTRUCTION MANUALS

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- ☐ Directions for Laying Galvanized Sheets
- ☐ Metallic Zinc Paint Protects Metal Surfaces

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Rigid inspection of all Acme Chains is a guarantee that every foot of chain you receive leaves our plant in perfect mechanical condition.

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FOR QUICK SERVICE

The ACME Organization was built to give prompt and immediate service. The flexibility of our equipment, the crew of skilled mechanics, our large inventory of standard sizes of ACME Chains, and good shipping facilities, all go to give you ACME Chains when you want them — where you want them.

When you want Roller Chains in a hurry, phone Holyoke 2-9458 and we'll do all we can to help you.

Write Dept. 9M for new illustrated 76 page catalog on use and application of roller chains and sprockets.

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Personnel Service Bulletin

(Continued from page 678)

AGRICULTURAL ENGINEER for design, development, research or writing in farm structures or soil and water field with industry or public service, anywhere in U.S.A. Location in U.S. possessions considered. Some travel acceptable Married. Age 24. No disability. BS deg in agricultural engineering, 1952, University of Illinois. Farm background, pre-graduation experience in carpentry; survey analysis and office work with rural electric co-op, one summer; time and travel study with USDA. Since graduation, 26 mo on aircraft structural design with major manufacturer. Available on 3 weeks notice. Salary $5000+. W-299-151

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the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong". Wear it.

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With blue ground for Fellows, Members, and Associate Members — furnished either in pin with safety clasp or lapel button — $3.50 each.

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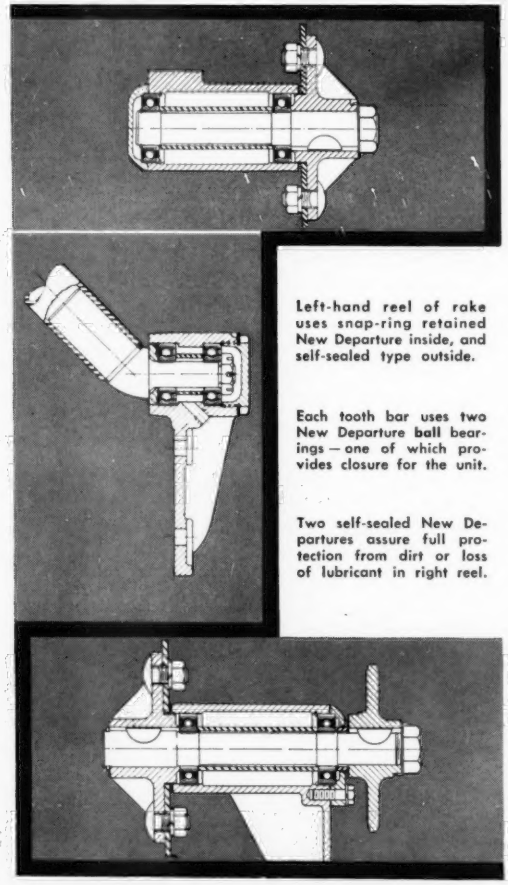
Send orders to ASAE, St. Joseph, Michigan.

IN CASE THEY WANT THE BEST...



Left-hand reel of rake uses snap-ring retained New Departure inside, and self-sealed type outside.

Each tooth bar uses two New Departure ball bearings — one of which provides closure for the unit.

Two self-sealed New Departures assure full protection from dirt or loss of lubricant in right reel.

THEY SPECIFY NEW DEPARTURE BALL BEARINGS

In Case's No. 100 Side Delivery Rake, 20 New Departure **ball** bearings simplify design, help reduce manufacturing costs . . . keep service requirements to a minimum. In both left- and right-hand reels the New Departure bearings are snap-ring-located, providing positive shaft location and avoiding unnecessary machining costs. Outer bearings are sealed type for additional protection from dirt or loss of lubricant. On each of the eight tooth bars, New Departures provide similar economies and protection for long-life operation.

Learn the advantages New Departure *ball* bearings can bring to *your* farm equipment. Talk with your New Departure engineer—*today!*

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NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Plants also in Meriden, Connecticut, and Sandusky, Ohio
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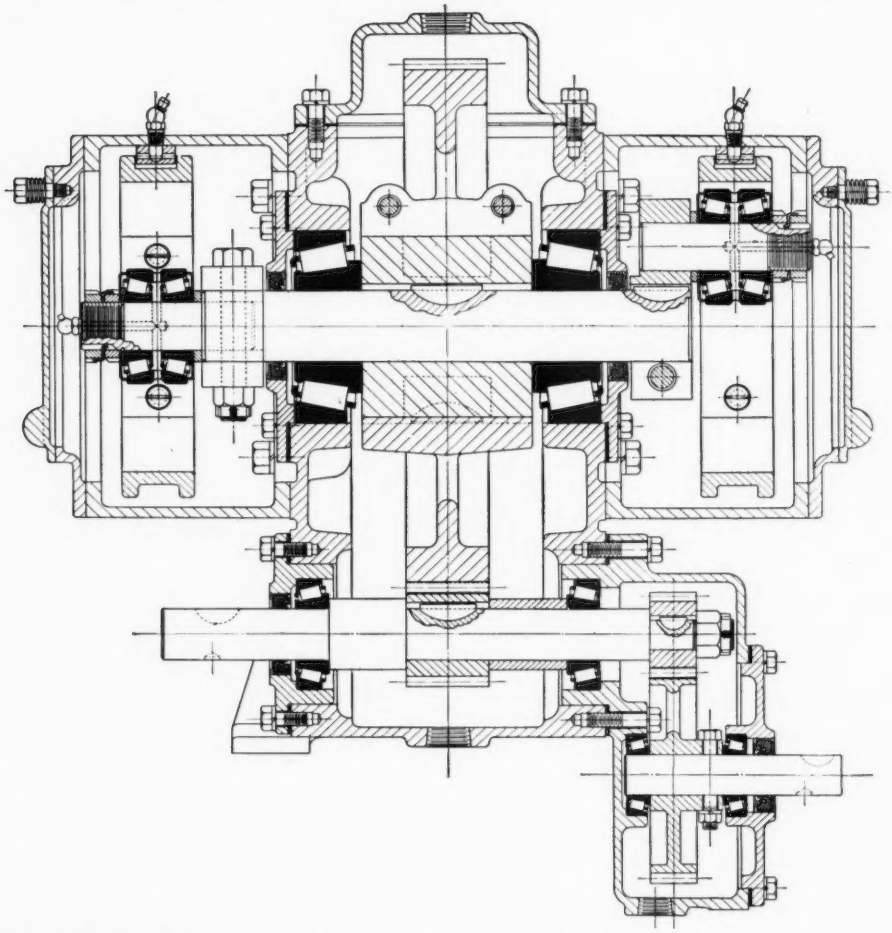
EVERY MAKE OF FARM TRACTOR HAS TIMKEN BEARINGS; MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!

How Timken® Bearings in Friend Pump take Heavy Shock Loads, Keep Gears in Accurate Mesh



IN this pump made by Friend Manufacturing Company, Inc., the crankpin moves the scotch yoke which drives the plungers. One of the design problems of Friend engineers was how to take the heavy shock loads caused by the yoke's constantly reversing direction of forces.

This problem was solved by mounting Timken® tapered roller bearings on the crankpin. Full line contact between the rollers and races of Timken bearings gives them extra load-carrying capacity. And these bearings are case-carburized to give a hard, wear-resistant surface over a tough, shock-resistant core.

Friend also mounts the crankshaft, pump drive shaft and agitator drive shaft on Timken bearings to maintain accurate gear contacts throughout the pump. Timken bearings give the shafts maximum rigidity. And because of their taper, Timken bearings take radial and thrust loads in any combination. Gears keep in accurate mesh, minimizing wear.

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The farmer's assurance of better design

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